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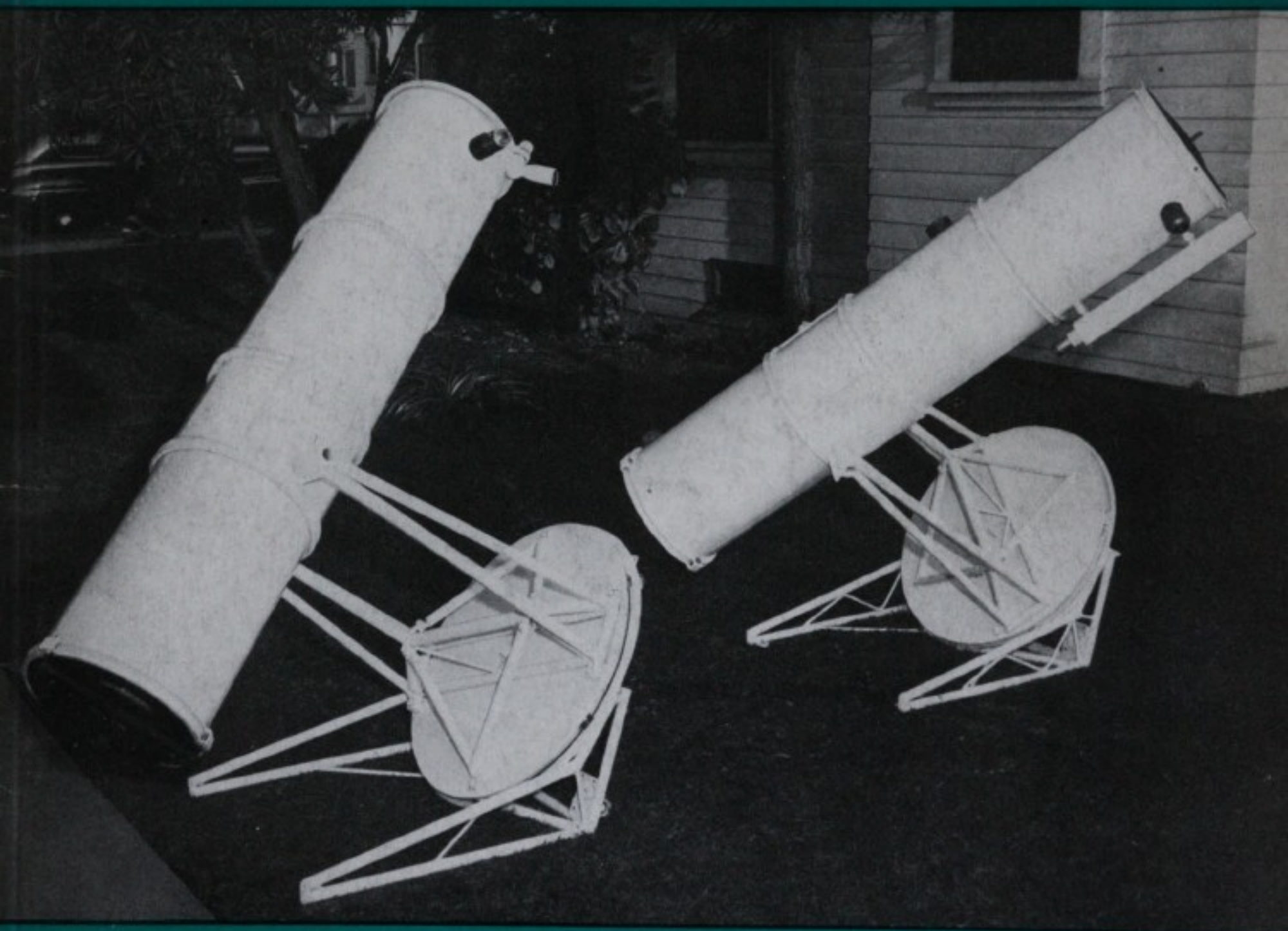

Twin 12½-inch portables

In This Issue:

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Vol. XV, No. 5

MARCH, 1956

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Amateurs to Observe Satellites

American Astronomers Report

Wolf-Rayet Stars

A Tribute to Robert Frost

Stars for March

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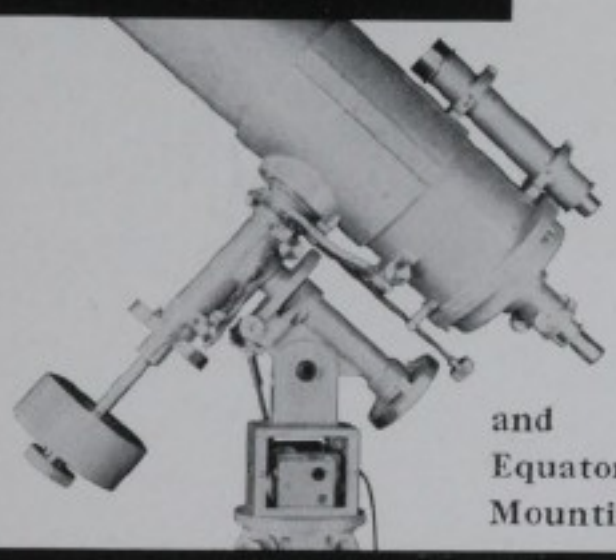

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Sky and TELESCOPE

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The principal articles are indexed in THE READERS' GUIDE TO PERIODICAL LITERATURE.

Plans for a Large Radio Telescope

ALTHOUGH radio astronomy began in the United States, we are lagging behind other nations in the construction of large radio telescopes with parabolic antennas. Among the versatile dish-shaped receivers now in operation in this country are one of 50-foot diameter at the Naval Research Laboratory in Washington, D. C., the 27-foot antenna of the Carnegie Institution of Washington, the National Bureau of Standards' 27- and 21-foot receivers, and the 25-foot instrument of Harvard's Agassiz station in Massachusetts.

Already under construction are an 84-foot radio telescope for the Naval Research Laboratory, and a 60-foot at Harvard. Plans are under way for large receivers to be erected in California. But even these instruments will prove too small for some important present-day problems in radio astronomy, and none is in a class with the giant 250-foot parabola now being erected in England (*Sky and Telescope*, November, 1955, page 21) and a similar instrument being set up in Australia.

The cost of such immense radio telescopes is too great for observatory or institutional budgets, and government support appears necessary. Consequently, in his January budget message to Congress, President Eisenhower asked that $3,500,000 be appropriated to the National Science Foundation to construct a 140-foot parabola in the eastern United States, this instrument to be available to all astronomers for basic research. Designs for this instrument are already in an advanced stage.

The National Science Foundation, through its advisory panel on radio astronomy, headed by Dr. Merle A. Tuve, Carnegie Institution, has been studying the problem for two years. The initial studies have been carried out by the Associated Universities, Inc., whose working committee has been under the chairmanship of Dr. Bart J. Bok, of Harvard Observatory. This group of nine eastern universities may possibly operate the new radio astronomy observatory.

The 140-foot radio telescope will probably be located in the Appalachian Mountains, at one of six sites that are under consideration in a region extending from southeastern West Virginia into the Carolinas. A major factor in the choice is freedom from radio and television interference. There is a possibility of future construction of a mammoth 500- or 600-foot antenna, and an eventual expenditure for the observatory of 25 or 30 million dollars.

SOME LUNAR CRATER PROBLEMS

PATRICK MOORE, *Lunar Section, British Astronomical Association*

THE MOON is so close to us, cosmically speaking, that it seems at first sight as if we should know all that there is to know about it. Unfortunately, this is far from being the case.

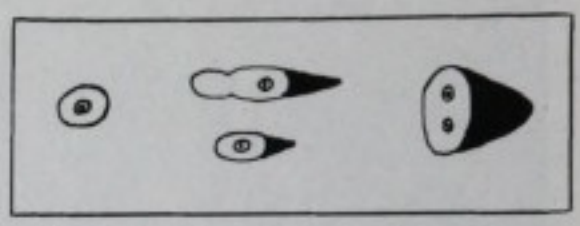
Astronomers are still speculating as to its origin, and there are many points about the moon's present physical condition that remain to be cleared up. What, for instance, are the curious patches of whitish "mist" seen from time to time, and what are the equally curious dark bands in some of the bright craters?

But perhaps the most baffling problem of all is that of the origin of the surface features. Opinions are sharply divided upon this point, and there has been a great deal of argument in recent years, some of it strangely heated.

Everyone is familiar with the general features of the moon: "seas," mountains, ridges, gaping cracks or clefts, and, most important of all, the ringed formations that we call craters for want of a better name. The mountain ranges seem basically similar to those of the earth, and there is little reason to suppose that they were formed in any but the same fashion; neither do the ridges and other minor features give much trouble. It is the craters which, so far, have not been satisfactorily accounted for.

Many theories have been put forward. Some, such as the crystallization hypothesis of K. H. Engel (*Sky and Telescope*, November, 1949, page 6), are of great interest. Others, such as the ice banks of P. Fauth and the coral atolls of D. P. Beard, are fantasies. But on the whole, there are only two theories that we need consider, the meteoritic and the volcanic.

The first of these, which attributes the craters to the impacts of great meteorites upon the lunar surface, was originally put forward a century ago by F. von Gruithuisen, forgotten for a time, revived by the English astronomer R. A. Proctor (who, however, abandoned it later in his career), and is still in high favor with theoretical writers. In its most perfect form, it has been dealt with in R. B. Baldwin's book, *The Face of the Moon* (1949), which is of immense value and a masterpiece of clear, concise writing. Impacts are believed by Dr. Harold C. Urey, of the University of Chicago, to explain such large-scale features as Mare Imbrium, as described by him in the January and February issues, this year.

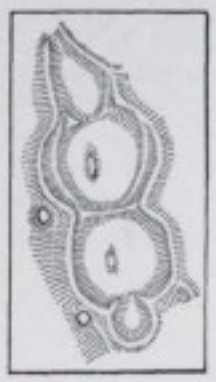


These drawings of summit craterlets are by the author, from observations at Meudon. Left to right are shown the central peak of Burg, two peaks east of Archimedes, and the central peak of Alpetragius.

The Hyginus cleft as a craterlet chain. Drawn by D. W. G. Arthur for the "Journal" of the British Astronomical Association.

The first strong point of the meteoritic theory is that lunar craters are not in any way like most terrestrial volcanoes. Furthermore, meteorite craters are known upon the earth: the great ones in Arizona, Australia, and Estonia. These are much more like lunar craters in form, and explosion pits made by shells and bombs are also similar with regard to their depth-to-diameter ratios. If we draw a graph, plotting depth against diameter, the lunar craters, terrestrial meteorite craters, and explosion pits will all lie along a smooth curve.

FACING PICTURE: This is the second of a series of four sections of the 4.6-day-old moon, the first of which appeared in February. Mare Foecunditatis is central in the picture, with the crater Langrenus, 85 miles in diameter, lying along its western (left) edge. A portion of Mare Crisium is seen at the bottom. Other features may be identified from the lunar map published in January and now available as a separate reprint. This photograph is enlarged from a negative taken with the 36-inch Lick refractor on June 2, 1938. Lick Observatory photograph.



The crater chain of Vogel, drawn by D. W. G. Arthur, extends across 1/50 of the moon's disk. South is upward. From the "Journal" of the British Astronomical Association.

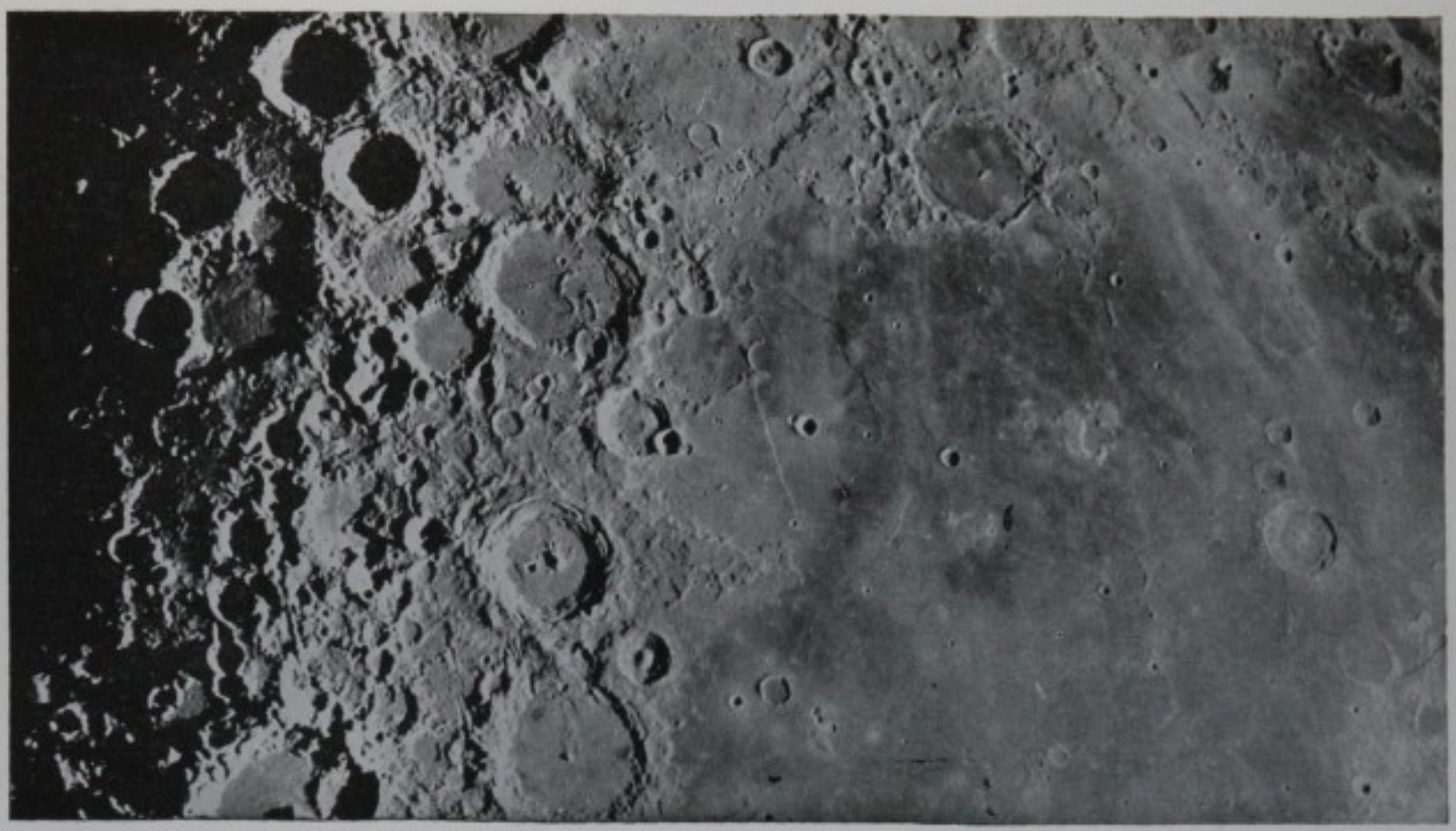
Unluckily, none of these strong points is quite so strong as is often made out. It is not seriously suggested by the volcanists that the lunar craters are true volcanoes; they are more likely to be subsidence products, we are told, and there are similar features on our own planet. Erosion may have destroyed evidence of other such terrestrial craters, and in any case even the meteorite craters are rare on the earth.

The answer to the depth-to-diameter relation is that explosions taking place below the ground also produce craters that lie along the same curve; thus the curve may mean only that the lunar craters were formed by some fairly violent process—which is obvious enough anyway.

The meteoritic theory is also vulnerable with regard to the distribution of the craters, which is not at random; there are pairs, double craters aplenty, and large numbers of chains of craterlets whose walls are in contact. Sometimes the adjacent walls are actually destroyed, and it is not easy to tell the crater chain from a cleft. D. W. G. Arthur has dealt fully with this problem (*Journal* of the British Astronomical Association, *60*, 6 and 162, 1950).

Even some great walled plains fall into well-marked lines. One such line consists of six vast formations from Ptolemaeus to Walter; another is the great western chain from Furnerius to Cleomedes, and there are many more. Baldwin admitted a volcanic origin for the tiny craterlets in chains, but it is significant that these are, individually, just like any other craterlets, so that it seems very unlikely that they had an origin which was fundamentally different.

Moreover, hilltop or summit craterlets are found on the tops of mountains, both on the central peaks of large formations and on isolated hills. According



In this portion of a Mount Wilson Observatory photograph, the western edge of Mare Nubium is seen bordered by the central chains of large craters marked by Mr. Moore on his diagram. The Straight Wall is in the center of the picture. Within the mare are some ghost craters.

to the meteoritic theory, these are mere chance hits. On this basis, about 15 summit craterlets should be known, which fitted in well enough with observation until recently.

Within the past five years, H. P. Wilkins and I have carried out extensive lunar observations with the largest refractor in Europe, the 33-inch of the Meudon Observatory, near Paris. (This is the instrument with which E. M. Antoniadi did most of his work.) Between us, we have recorded dozens of new summit craterlets, and it is safe to say that they are really quite common, but so minute that they need apertures not available to most observers. A single summit craterlet is always central on its mountain; if there are two craterlets, as on the top of the central peak of Alpetragius, they are placed symmetrically. We can therefore dismiss the idea of chance hits completely, and on the meteor theory these summit craterlets seem very hard to explain.

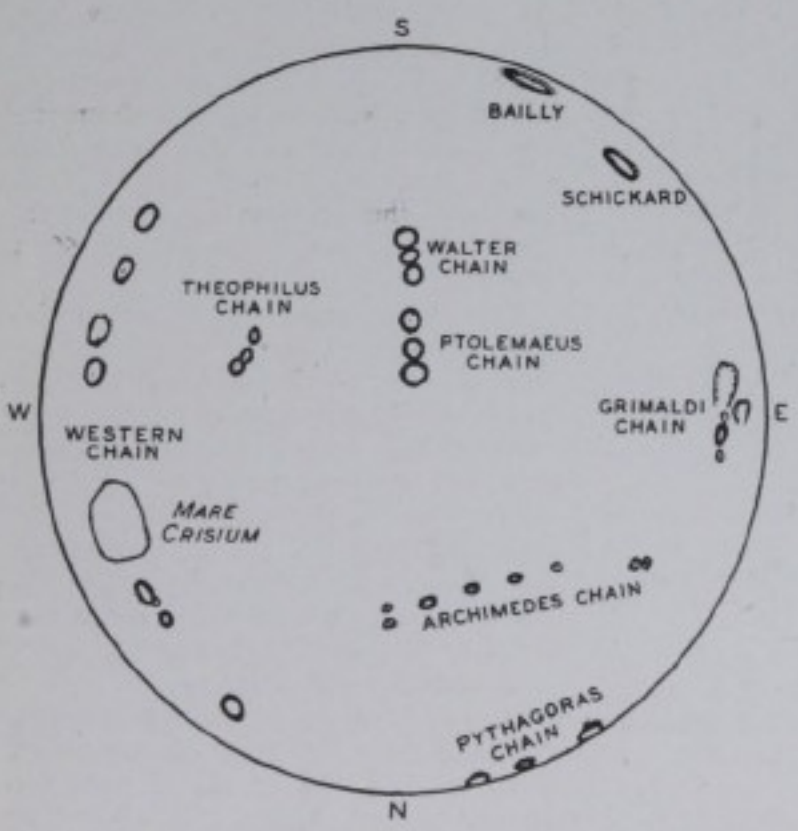
In general, it appears that the meteoritic theory is supported mostly by those who have little practical experience in lunar observing. The study of photographs, by itself, is not enough. But is the volcanic theory any more plausible?

The old "volcanic fountain" idea of Nasmyth and Carpenter in 1876 held that the crater walls were built up by spraying material from a central volcano. This explanation has fatal weaknesses, but other volcanic theories have been put forward. Some recent ideas have been outlined in my book, *Guide to the Moon*, 1953.

It seems to me that millions upon millions of years ago, while the earth still lacked any form of life, the moon must have had a more-or-less solid crust, overlying a layer of viscous, hot lava. At any weak point, lava would tend to force its way through the crust, to form a feed pipe, and before long the whole area would be lifted by an uprush of gas, forming a dome.

If the pressure relaxed at this point, there would be no further development, and the dome would remain as evidence of a crater that never properly formed. Many domes of this kind can be seen upon the moon today. But usually so much gas would be forced out through the feed pipe that the pressure below would fall abruptly, and the dome subside with comparative suddenness. This would lower it into the hot lava, melting the skin of the old dome.

After this had happened several times, there would be a depression with walls high above the interior but low above the outer country; the inner walls would be terraced, and minor craters and hills



The tendency of large lunar craters to form well-marked chains is indicated in this diagram by Mr. Moore. If the craters had been formed by meteoritic impacts, their arrangement should be more-or-less random.

would spring up on the congealing floor. Often the dying ejections from the old feed pipe would build up a central elevation, though in other cases a final phase of remelting would destroy all the features of the floor.

On this theory, some of the maria, the well-defined, circular ones such as Mare Crisium and Mare Imbrium, are simply giant craters; the shapeless, patchier seas are mere lava overflows from the great dome collapses. Craters formed on the seas before the surfaces properly solidified again, such as the famous Archimedes, had their floors remelted before they could attain much depth, while other older craters were overwhelmed and now appear only as ghost rings.

Gradually, uplifts and collapses became smaller and fewer as the inner energy died down. So much material was withdrawn from beneath the crust that the whole crust crumpled, with the formation of mountains far higher relatively than those of the earth. Finally, when most of the activity was at an end, there came explosions from the peaks of some of the still-living craters, which scattered the long streamers of ash called rays.

There are a few other features that

Wargentin, the "plateau" crater, appears to have been filled by a flow of lava welling up from beneath. This rather idealized representation is from Nasmyth and Carpenter, "The Moon," of 1876.

can be explained by volcanism on the moon much more easily than by impact, such as the curious lava-filled crater known as Wargentin. But weaknesses still remain in any theory, in plenty. The queen of night guards her secrets well. One day, when men land upon the moon, the barren, desolate lunar rocks may tell us their story. Until then, we must keep open minds. Meteorite falls and volcanic activity may both have played their part in molding the moon.

Amateurs to Observe Satellites

AMATEUR ASTRONOMERS have their work cut out for them when the first artificial satellite of the earth is launched sometime during the 1957-58 International Geophysical Year. Their experience in observing the heavens with simple equipment will be very valuable in aiding astronomers to keep visual track of what may prove to be a quite elusive celestial object.

The optical satellite-tracking program has been assigned to the Smithsonian Astrophysical Observatory, Cambridge, Mass., by the National Academy of Sciences. The associate director of the project, Dr. J. A. Hynek, will co-ordinate the program. He has designated the Astronomical League, the American Association of Variable Star Observers, the Western Amateur Astronomers, and the International Astronautical Federation, as collaborating agencies for satellite observations by nonprofessional observers.

A communications network, probably with the aid of amateur radio operators, will be established for the transmission of observations as soon as they are made; by the same means observers will receive direct information on predicted satellite positions and optimum observing times. *Sky and Telescope* expects to publish data on observing equipment and methods, and on standardized reporting procedures. Adaptation of wide-angle instruments already possessed by amateurs, such as binoculars and rich-field telescopes, will be important.

Amateur astronomers who wish to be official satellite observers should make application through their local astronomical societies, or through one of the above-named organizations. The Astronomical League has appointed a satellite-tracking program committee with G. R. Wright, Silver Spring, Md., as chairman. Other members are E. A. Halbach, Milwaukee, Wisc., R. R. LaPelle, Meadville, Pa., C. H. LeRoy, Pittsburgh, Pa., and R. C. Maag, Sedalia, Mo.

In a talk before the Institute of Aeronautical Sciences in New York City, on January 25th, Dr. Fred L. Whipple, director of the Smithsonian Astrophysical Observatory, said that there would be specially designed telescopes at 12 or more strategically selected places around the world, for precise tracking and timing of the satellites. These stations, however, cannot begin to gather data until the initial path of the satellite has been plotted. Nor can they follow the extremely rapid orbital changes during the last hours of the satellite's flight.

"The first observations of the satellites after launching and the last before the satellites spiral to earth will be the most important," Dr. Whipple said. "A world-wide corps of sky watchers will be needed for this purpose. The importance of amateur astronomers in the project can hardly be overestimated, and the entire satellite project offers sky watchers an unparalleled opportunity to be of significant service to science."

Although each satellite will be fitted with radio transmitting apparatus designed to facilitate radio tracking, such equipment may not withstand the stresses of the flight up to the orbit. If the radio equipment fails, the amateur visual observations may become the only means of locating it. The observers will probably work in groups, using binoculars or wide-angle telescopes set to cover overlapping parts of the central region of the sky. The favorable periods for spotting the passing satellite will be at dawn and dusk, when a group expecting passage near its zenith will maintain a constant vigil for a stated period, each observer using his particular stationary instrument.

The path of flight relative to the stars will be reported to an area captain and thence to a central headquarters, where it will be combined with other observations and fed as data into an electronic computer, which will calculate the satellite's orbit. Then the telescopically equipped observing stations will go into operation. About eight of them will be staggered along a meridian running through the eastern United States down through South America.

This will provide coverage over the latitudes between which the satellite is expected to pass, roughly 40° north and south. It will be launched from Patrick Air Force Base in Florida, toward the southeast at an angle with the equator of about 40 degrees. It will pass into the Southern Hemisphere, back across the equator to a maximum northerly latitude of some 40°, thence south again. But its path will precess westward as the satellite flies, so that on each 90-minute round trip it will cross new places. Therefore, it will be located at some time or other over the United States, Central and South America, Africa, southern Europe, the Balkans and the Middle East, part of the Soviet Union, eastern Asia, Australia, and New Zealand. Large as it is, this area does not include all of the 42 nations participating in the International Geophysical Year, but later satellites may fly nearer to the poles than the first one.

The first satellite is expected to be 30 inches in diameter, and to weigh about 21½ pounds. About half will be the weight of the metal sphere, the other half that of the instruments and radio transmitter. Its internal temperature cannot be predicted, and may range from below zero to 300° or 400° Fahrenheit. There is probably not much danger of damage from meteors, which are mostly the size of dust grains. Other details about the satellite were published in the January issue, page 112.

NEWS NOTES

By Dorrit Hoffleit

ORIGIN OF METEORITES

Several current theories on the origin of meteorites have been critically examined by E. J. Opik in the *Irish Astronomical Journal*. That meteorites are fragments of a once larger body seems beyond doubt. They appear to have originated from the interior of planets between the sizes of Ceres and the moon, and to have been formed under pressures of tens of thousands of atmospheres. The evidence that iron and stony meteorites were thus formed comes from the Widmanstätten patterns of iron meteorites, and from the theoretical rate of cooling of a solid sphere.

To explain the breakup of the original body, neither tidal stresses nor internal disruption because of an unstable planetary core appears to be adequate. The only efficient mechanism, according to Dr. Opik, is collision with another body. He finds that the collision of a 1,500-kilometer-diameter body with another of 600 kilometers would be sufficient to destroy both, if they were moving at a relative velocity of only five kilometers per second. The fragments would later collide with one another, increasing their number and decreasing their average size, thus accounting for masses from asteroids down to dust.

Asteroids crossing each other's orbits would collide at relative velocities of the order of six kilometers per second. In the outskirts of the solar system, however, breakup by collision is less likely, because the relative velocities are much lower. Were Pluto to collide with Neptune, the result would probably be a single body with their combined masses. While collisions of small planets are the most likely mechanism to account for meteorites, such events happened presumably in the inner rather than the outer parts of the solar system.

ANTIPROTON DISCOVERED

The antiproton, a negatively charged elementary particle having the same mass as the proton, has been discovered experimentally at the Radiation Laboratory of the University of California in Berkeley. The discovery was made by O. Chamberlain, E. Segrè, C. Wiegand, and T. Ypsilantis, with the aid of the Atomic Energy Commission's particle accelerator, the bevatron.

Ever since the theoretically predicted existence of antielectrons (now called positrons) was confirmed in the laboratory by C. D. Anderson in 1932, detection of the corresponding antiproton has been anticipated. The main reason this particle was not found sooner is that it does not occur in the atomic nucleus, but is created by high-energy collisions. Until the bevatron was built, bombardments of sufficient energy to produce antiprotons were not possible in the laboratory.

The experimenters accelerated protons to energies of 6.2 billion electron volts, allowing the beam to fall on a copper target. On colliding with a neutron in the target, a proton with this high energy could spend part of it to produce a pair of particles: another proton and an antiproton.

Of the varied particles ejected from the target, the physicists had to distinguish between pi-mesons, moving at very nearly the speed of light, and antiprotons with 75 per cent of this speed. It was found that, mingled with the mesons, one in each 44,000 particles had just the right speed for antiprotons.

Two methods for measuring the speeds were used. In the first, particles were observed in two counters placed 40 feet apart, and the time of flight was measured. As a check, special Cerenkov counters were designed, which registered only particles at a particular speed.

The newly found particle has the same mass as the proton (within five per cent), and a negative charge. Since their discovery in September, hundreds of antiprotons have been produced by the bevatron.

The properties of the antiproton are known theoretically in much detail. In a vacuum, the particle is stable, but on colliding with a proton both particles decay into mesons and disappear. Experimental studies of this annihilation process are being carried on. Already, bursts of energy and matter resulting from such collisions have been observed as "stars" in photographic emulsions. In one eight-pronged star there were ejected five heavy particles, either protons or alpha particles, and two mesons; neutrons probably also emerged, but they were not visible.

With the discovery of the antiproton, the existence of still another particle, the antineutron, becomes virtually certain.

ELLIPTICAL GALAXIES

An investigation of the distribution of surface brightness in each of a dozen elliptical galaxies has been carried out by W. A. Baum of the Mount Wilson and Palomar Observatories. Measurements with modern photoelectric equipment indicate that such galaxies are considerably larger than was previously thought; Dr. Baum even suggests that galaxies may blend into one another with no vacant gaps between them. This seems confirmed by photoelectric measurements of surface brightness in intergalactic regions within the remote cluster of galaxies at $9^h\ 25^m$, $+21°$. In any case, the tenuous outskirts of an elliptical galaxy make the assignment of a total magnitude difficult.

Dr. Baum has studied in detail M87 in Virgo, a typical bright elliptical containing over 1,000 globular clusters. Here the distribution of the clusters roughly matches the falling-off in surface brightness in the galaxy with increasing distance from its center. He concludes that the distribution of mass should be the same as the distribution of the luminosity, and that the brightness profile of the galaxy should change little with time. This means that on the average the apparent size of an elliptical should be a reliable index of distance. Distances based on apparent magnitudes, on the other hand, cannot be trusted.

In M87 the brightnesses of globular clusters indicate a distance modulus of 30.2 magnitudes, corresponding to a tentative distance of 10 million parsecs. This is roughly four times the previously accepted value.

Comparing apparent sizes in the Virgo cluster with those in more remote clusters of galaxies, Dr. Baum infers that the red shift increases about 150 kilometers per second for each million parsecs of distance. This indicates an age of 6.5 billion years for the expanding universe.

This work was reported in the October, 1955, issue of the *Publications* of the Astronomical Society of the Pacific.

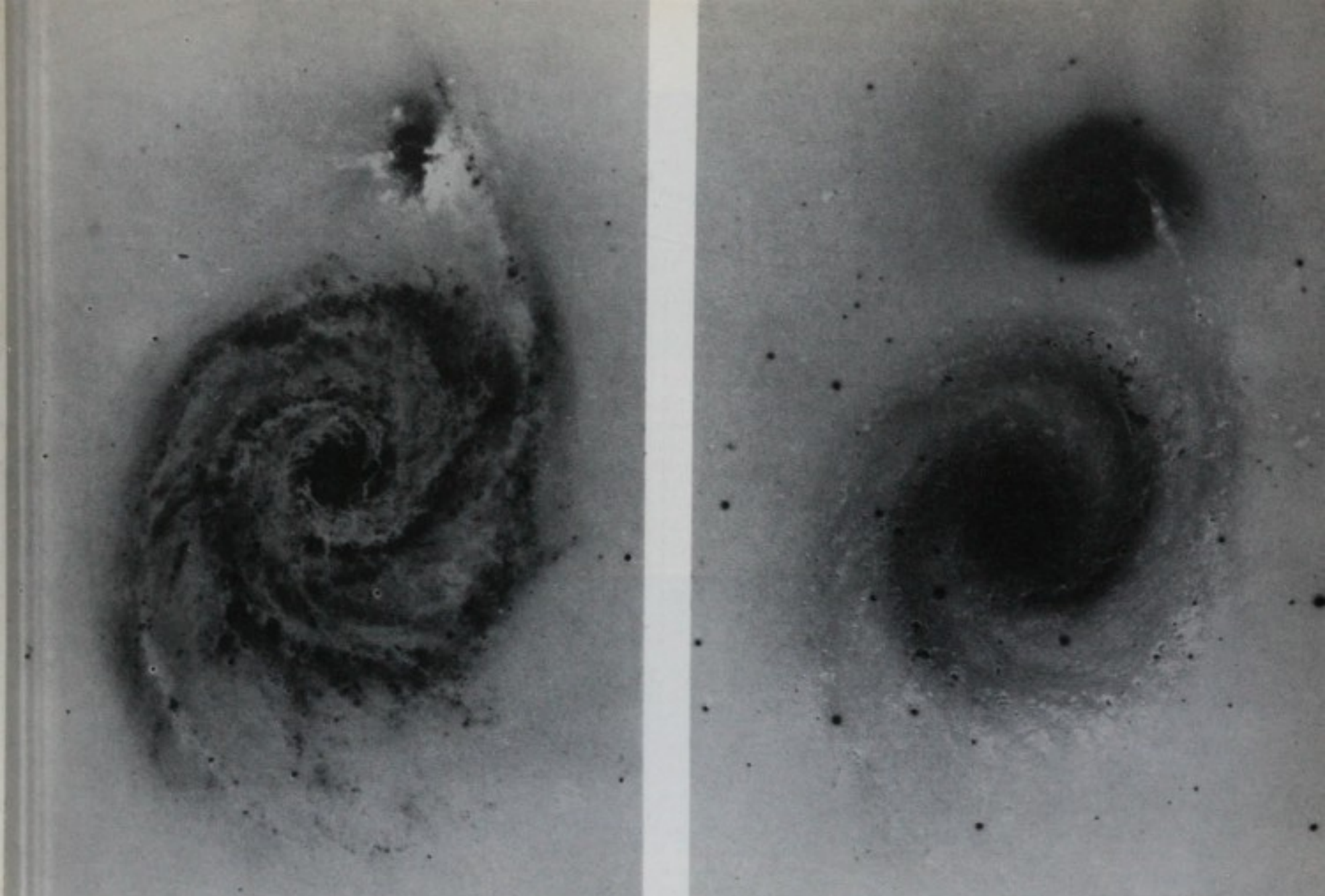
IN THE CURRENT JOURNALS

SOLAR "FACTORY" IN THE PYRENEES, by Daniel Behrman, *Science Digest* (reprinted from *UNESCO Courier*), February, 1956. "At Mont-Louis, 5,250 feet high in the eastern Pyrenees near the Spanish border, zirconia, which is used in lining furnaces—and other refractory materials—are being produced by solar energy at a cost 25 per cent lower than that of conventional electric-arc methods."

METEORS, by Fred L. Whipple, *Publications* of the Astronomical Society of the Pacific, December, 1955. "We can class these meteoritic projectiles according to size as follows: micrometeorites, telescopic and radio meteors, photographic and visual meteors, fireballs, detonating bolides, meteorite falls, and finally, meteorites that produce craters. . . . To complete this discussion, we can bring together radio meteors, photographic meteors, the zodiacal light, micrometeorites, comets, and corpuscular radiation from the sun."

GIORDANO BRUNO AND THE INFINITE UNIVERSE, by Warren Hollister, *Griffith Observer*, December, 1955. "Born five years after the death of Copernicus, Bruno died ten years before the publication of *Sidereus Nuncius* in which Galileo reported his first telescopic discoveries, yet in a sense this wandering Dominican had greater vision than either Copernicus or Galileo."

THE NEUTRINO, by Philip Morrison, *Scientific American*, January, 1956. "The neutrinos in us and all around us come from the deep interior of the sun, where they are born in the same nuclear reactions that make the sun shine."



These composite photographs of the galaxy Messier 51 in Canes Venatici were obtained by F. Zwicky with the 200-inch telescope at the Palomar Observatory. The scale is 4.9 seconds of arc per millimeter. The left-hand picture accentuates blue detail, the other the structure in yellow light. Mount Wilson and Palomar Observatories photographs.

COMPOSITE PHOTOGRAPHS OF THE WHIRLPOOL NEBULA

At Mount Wilson and Palomar Observatories, Dr. Fritz Zwicky has been applying what he calls analytical photography to studies of the distribution of stars and nebulosity in our own and other galaxies. His work was briefly described in a news note in February, 1954, page 112. He now has obtained excellent results in the case of the famous Whirlpool nebula, Messier 51 and its companion system, NGC 5195, and has published a discussion of these in the *Publications* of the Astronomical Society of the Pacific.

Two composite photographs are reproduced here. They are made from a pair of plates, one with an ordinary blue-sensitive emulsion, the other with an orthochromatic emulsion exposed through a yellow filter. Their exposure times have been adjusted so that corresponding images of *O*- and *B*-type (blue-white) stars are of the same size on both pictures. The images of orange and red stars are then larger on the yellow plate than on the blue one.

Using the proper exposure time, a positive transparency of the yellow plate was then made, the resulting white images of very blue stars being identical in size with their black counterparts on the blue negative. The left-hand picture shows the effect of superimposing this yellow positive on the blue negative. When the procedure is reversed, with a blue positive superimposed on the yellow negative, the right-hand picture is obtained. Very blue stars appear as black spots on the left, but as white spots on the right. Very red stars are white spots on the left, and black on the right. Stars of intermediate colors give black spots surrounded by white rings, the relative diameters being a measure of blueness or redness.

A glance shows that these composites are very different. Much more detail is seen in the blue-negative yellow-positive combination. Bright blue stars of Population I are distributed unevenly along the galaxy's spiral arms. The irregular companion galaxy, across which one of the Whirlpool's spiral arms extends, is smaller in blue light than in yellow.

On the blue-positive yellow-negative composite, on the other hand, the spiral arms shown by the black images of unresolved red stars are very smooth and well defined, suggesting a higher degree of organization of the fainter Population I red stars than of the blue supergiants in the same regions of the Whirlpool galaxy. The companion appears large in this combination, and shows none of the structural detail seen in the left-hand picture. Dr. Zwicky points out, however, that different galaxies have different relative distributions, and that some which look almost identical on single direct photographs may appear quite different by analytical photography.

CORRECTION TO NEWS NOTE ON DIAMETER OF PLUTO

An error was made in the editorial office of *Sky and Telescope* concerning the passage of the planet Pluto in front of the galaxy NGC 3162. In the News Note on page 159, last month, the date of Dr. Kordylewski's prediction was given as February 25, 1956, whereas the event will actually occur on March 25, 1956. A correction note to this effect was inserted in about half of the February edition before mailing.

AMERICAN ASTRONOMERS REPORTS

Here are highlights of some papers presented at the 93rd meeting of the American Astronomical Society at Troy, N. Y., in November. Complete abstracts will appear in the Astronomical Journal.

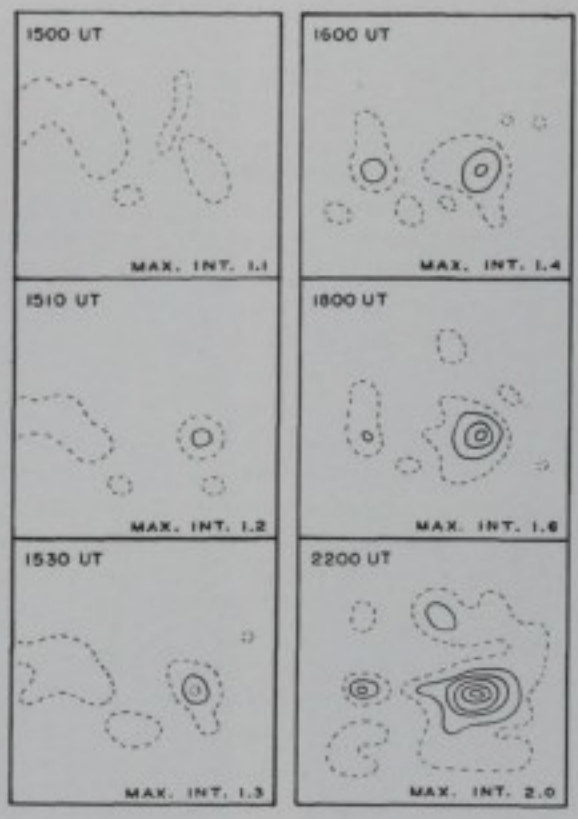
A Simple Case of Solar Activity

When the sun is just emerging from a minimum in its 11-year cycle of activity, there may occur opportunities to study an active solar region under conditions of unusual simplicity. Such a favorable occasion occurred from August 20th to 26th in 1954, and was described by Helen W. Dodson, of the McMath-Hulbert Observatory. Only a single disturbed region was present, as shown by the picture, and analysis of its complex phenomena was greatly simplified.

From 15:00 to 15:10 UT, August 20th, a small plage of luminous calcium vapor formed very close to the sun's central meridian, in about 30° south latitude. Three hours later a sunspot was visible inside the plage. Magnetic polarity observations of this sunspot group made at Mount Wilson Observatory showed that it belonged to the new sunspot cycle: this was to be expected because of the spot's high latitude.

During the next days, the calcium plage grew in area to at least 3/1,000 of the solar hemisphere. Photometric contour maps of the plage, from the McMath-Hulbert spectroheliograms, were compared by Dr. Dodson with geomagnetic, sunspot, coronal, and solar radio flux observations made in many parts of the world during the same days.

At least four flares were observed in this active region before it finally disappeared behind the western edge of the sun. Apparently, the earth's ionosphere did not undergo disturbances accompanying these flares, but an increase in solar radio noise at 200 megacycles seemed

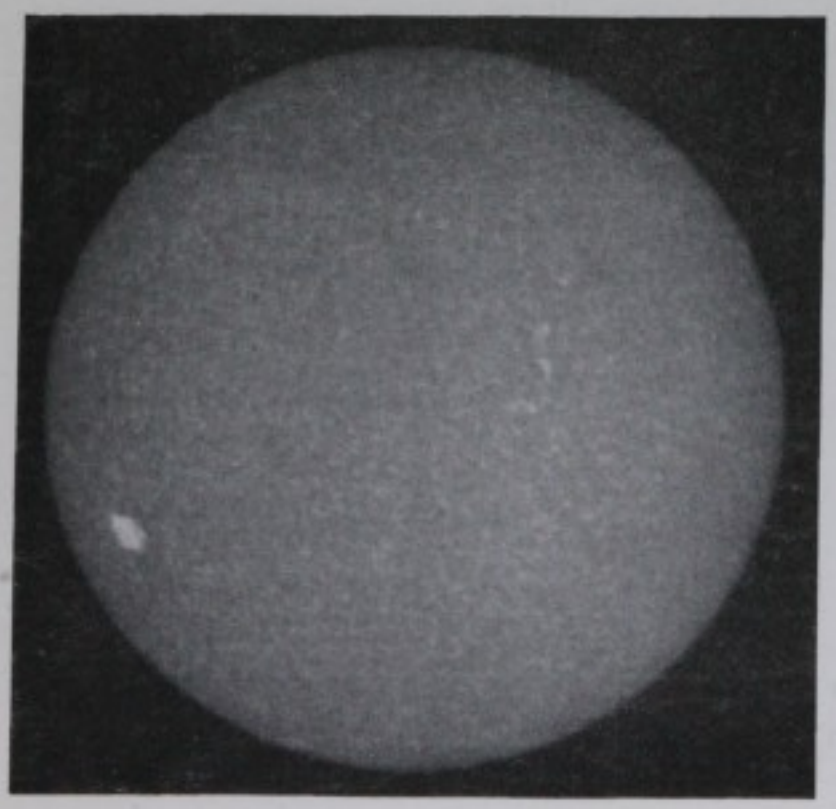


Six stages in the rapid birth of a disturbed region on the sun, August 20, 1954. These are McMath-Hulbert Observatory diagrams, based on spectroheliograms taken in calcium light.

associated with them. At 2,800 megacycles, however, excess radio radiation followed closely the increase in the visible brightness of the calcium plage itself. The first geomagnetic storm in four months started on September 1st, several days after the plage's limb passage.

All reports from observers of the solar corona during this period indicate that both the red and green emission lines in the coronal spectrum were especially bright in the neighborhood of the active region. However, the coronal data were not wholly self-consistent, and there were also problems in trying to reconcile the sunspot-area and radio flux observations from different observatories.

This was a very simple case of solar activity, said Dr. Dodson, but the difficulties in analyzing it give some indications of the problem of disentangling the varied solar data to be obtained during the International Geophysical Year in 1957-58, when the sun will be near maximum activity in its 11-year cycle and probably rarely free of several simultaneous disturbances.



The bright calcium plage is seen here at nearly its maximum size, shortly before solar rotation carried it out of sight. The remainder of the sun's visible surface is remarkably free from disturbances. McMath-Hulbert Observatory photograph.

The Motion of Venus and the Mass of Mercury

The orbit of Venus has been redetermined by R. L. Duncombe, U. S. Naval Observatory, on the basis of over 21,000 meridian-circle observations of the planet made between the years 1750 and 1949. The last previous discussion of the motion of Venus was by Simon Newcomb, more than half a century ago, and his results are still used internationally for ephemeris purposes.

The corrections to Newcomb's elements of the orbit of Venus are small, but one historic discrepancy has been removed—the observed rate of shift of the nodes of Venus' orbit now agrees with the predictions of gravitational theory.

As part of this investigation, Dr. Duncombe has redetermined the mass of Mercury; it comes out 1/5,970,000 that of the sun, with an eight-per-cent uncertainty.

Rotation of the Galaxy

The problem of the speed of rotation of the galaxy, as shown by stars in the vicinity of the sun, was discussed by Harold Weaver, Leuschner Observatory. His work is based on the motions of Cepheid variable stars, which are concentrated toward the galactic plane. He used precise proper motions of 79 Cepheids, newly derived by H. R. Morgan.

The generally accepted distance of the sun from the galactic center is about 8,200 parsecs (26,700 light-years). If this value is adopted, Dr. Weaver's Cepheid results indicate that stars in the solar neighborhood are moving at 190 kilometers per second in their orbital motion around the galactic center. A similar value of 216 kilometers per second had been found in 1954 by van de Hulst, Muller, and Oort, also based on the assumption of 8,200 parsecs.

However, several more direct methods of determining the orbital velocity indi-

cate strongly that it is larger. In 1946, N. U. Mayall analyzed the radial velocities of galaxies in the local group, finding 300 kilometers per second. The same method in 1955 gave Humason and Wahlquist essentially the same value: 292 kilometers per second. W. Fricke's 1949 study of the space motions of high-velocity stars led to 276 kilometers per second.

Although, as Dr. Weaver points out, these results contain some uncertainties, the discrepancy is clear: Direct methods give larger velocities than those using the assumption of 8,200 parsecs to the galactic center. One of the ways in which the inconsistency could be lessened would be an increase in the presently adopted distance to the center.

Shower Meteor Peculiarities

Each of the famous meteor showers has its own distinct peculiarities, indicating perhaps that they originate from different levels in their respective parent comets, according to the work of the Harvard Observatory meteor project and calculations by Luigi Jacchia. He described especially the strange case of two Draconid meteors. The Draconids come from Comet Giacobini-Zinner, and gave a bright but brief shower on October 9-10, 1946, widely observed by amateurs in the United States.

These two meteors were photographed simultaneously from Harvard's twin meteor stations in New Mexico on the night of October 8-9, 1953, with super-Schmidt cameras. They appeared one hour apart and are almost identical in length, brightness, and in their general appearance, which is the most extraordinary of any meteors ever recorded with the super-Schmidt cameras.

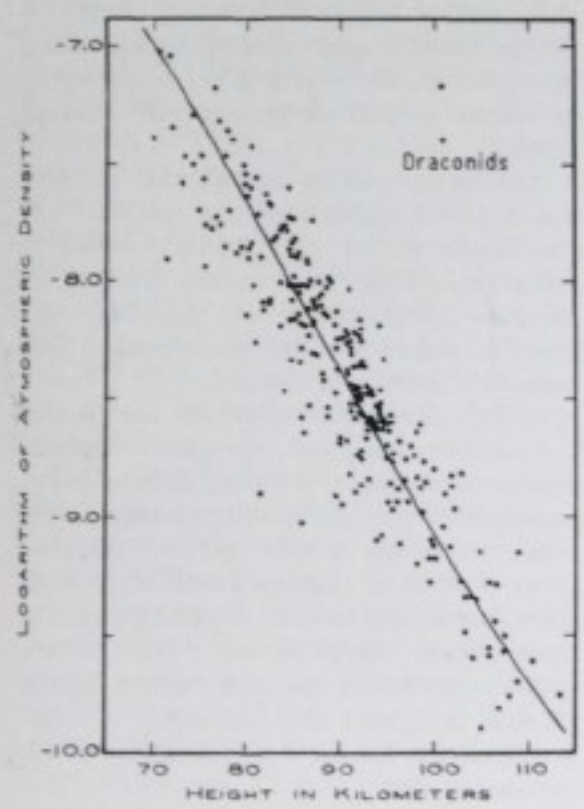
Normally, the trail of a meteor is chopped into bright and dark segments by a revolving shutter in the camera; this permits measurement of the angular speed of the meteor across the sky. But in these Draconid photographs, the shutter breaks are seen only in the first third of each trail and become progressively narrower; the rest of each trail is a continuous streak of light, although the shutter covered the meteor three quarters of the time, at 60 interruptions per second.

Dr. Jacchia explains these peculiar trails as caused by extreme fragmentation of the original meteor bodies. His associate, Richard E. McCrosky, pointed out that luminosity often seen in the shutter breaks of other meteor photographs may be due to small particles detached from the meteoroid and decelerating with respect to it. If so, much of the light would have to come from the fragments and not from the meteoroid directly. The particle sizes capable of producing the wake of a meteor are found to be of the order of 10^{-6} to 10^{-5} gram.

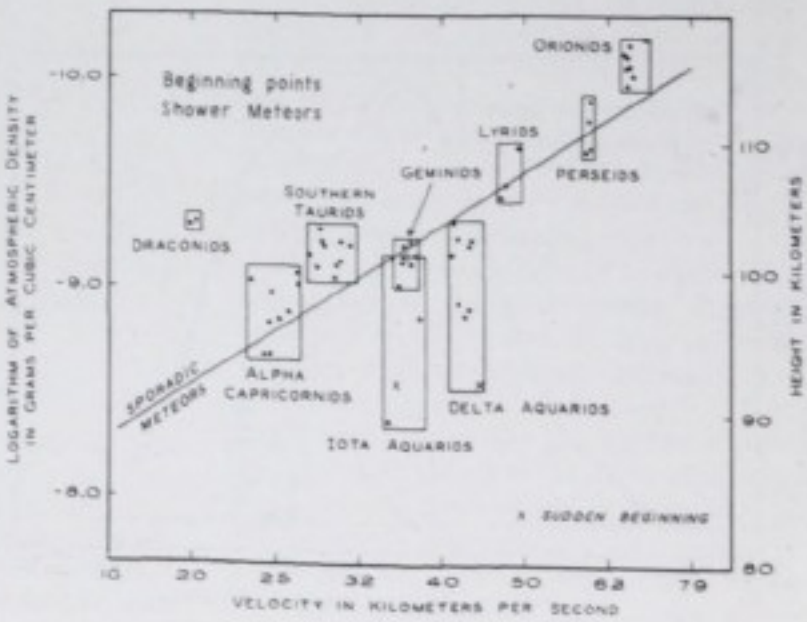
The fragmentation of the two Draconids is confirmed by their beginning heights of 104 kilometers, some 12 kilometers greater than the average beginning height of meteors with the same velocity of 20 kilometers per second. The decelerations by the atmosphere were respectively 53 and 91 times normal. These data confirm the exceptional results reported in 1950 by Dr. Jacchia, Z. Kopal, and P. Millman, for the Draconids of the 1946 shower.

The extreme fragility of the Draconids may be explained on the basis of the Whipple icy-conglomerate comet model,

In each of these two Harvard meteor photographs, of a peculiar Draconid (above) and a normal meteor (below), the meteor traveled from left to right. A rotating shutter in front of the camera provided 60 "looks" per second, each lasting 1/240 second. In the lower picture, the dashes are slightly elongated by persistence of the luminous wake of the meteoroid; for the Draconid, however, so much of the light comes from the wake that the dashes soon blend together. This seems to mean that the Draconid was so fragile it disintegrated into fragments. The scale of the lower picture is about 1½ times that of the upper. Harvard Observatory photographs.



Left: In this diagram showing atmospheric densities deduced from meteor decelerations, the two peculiar Draconids discussed by Dr. Jacchia lie far from the curve.



Right: Each of the nine groups of shower meteors plotted deviates systematically from the velocity-height relationship for the beginning points of sporadic meteors. Harvard Observatory diagrams.

if we assume that the meteors originated in the outer layers of the parent comet's nucleus, under relatively weak pressure. Dr. Jacchia said that Comet Giacobini-Zinner probably became a producer of meteors only in recent times, possibly after the great perturbation of its orbit by Jupiter in 1897, immediately preceding the comet's discovery.

Analysis of other showers indicates that the Taurid meteors have little tendency to break up. Their parent comet, Halley's, is large and old, so that present-day Taurids probably came from layers which originally were deep inside the nuclear ices.

A survey of beginning heights, decelerations, and fragmentation indexes for some of the major showers, based exclusively on super-Schmidt observations, shows that each shower has distinct peculiarities compared with the mean given by sporadic (non-shower) meteors. These deviations are in both directions, plus and minus, as the chart shows, with no systematically greater height of appearance for shower meteors.

Pleiades Cluster and Associated Neutral Hydrogen Gas

It would appear from a 21-cm. investigation by David S. Heeschen and Frank D. Drake, Harvard Observatory, that the hydrogen associated with the Pleiades cluster of stars is there as a result of an interaction between the cluster and the interstellar gas through which it is moving. The observations were made with Harvard's 25-foot radio telescope, which has a beam width of 1.7 degrees and a band width of three kilometers per second.

The 21-cm. records cover an area of 100 square degrees centered on the Pleiades. In the direction of the cluster, the line profile has two peaks, separated by six kilometers per second. There appear to be two concentrations of hydrogen, one with a line-of-sight motion toward us at two kilometers per second, the other away from us at six kilometers per second. The latter value agrees well with the mean radial velocity of the interstellar absorption lines observed in the spectra of Pleiades stars by W. S. Adams in 1949. The tie-in is obvious, and the interstellar spectral lines appear to be formed in the same extended region as that occupied by the hydrogen gas that produces the peak at +6 kilometers per second.

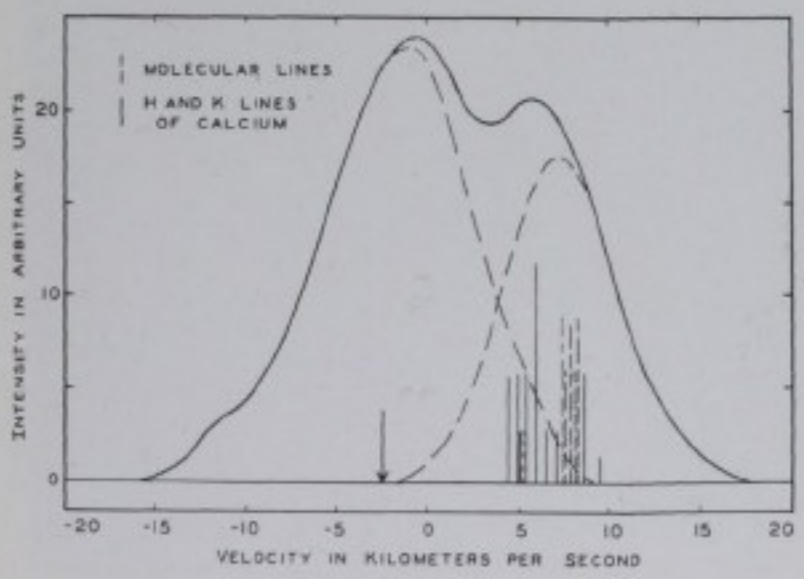
Furthermore, the positive radial velocity is recorded over all the region observed, whereas the negative velocity peak (−2 kilometers per second) is strongly present only within two or three degrees of the cluster. And the radial velocity of the cluster, previously found from optical studies, is about the same as that of the neutral hydrogen. Dr. Heeschen believes, therefore, that the negative-velocity concentration may be associated, both in space and in motion, with the cluster.

There is also an increase, near the cluster, in the amount of hydrogen with the negative velocity. This is accompanied by a corresponding decrease in the amount with the positive motion, as if the cluster stars were dragging some of the interstellar material along with them.

Two Monoceros Clusters and Interstellar Gas

Work at Harvard on the relationships between star clusters and interstellar hydrogen was reported by T. K. Menon, who has observed the regions of two clusters in Monoceros, using the same 21-cm. radio technique that David S. Heeschen and Frank D. Drake employed for the Pleiades.

One of these clusters is NGC 2244, embedded in the well-known Rosette nebula. Along our line of sight passing through this cluster Mr. Menon finds three condensations of interstellar neutral hydrogen gas; the second of these is at the same distance as the cluster, 1,300 parsecs. This gas forms part of a spiral arm of our galaxy, which appears to originate almost exactly at the location of the cluster. Mr. Menon points out that since the cluster and the gas condensation were presumably formed at about the same time, the observation may have some significance to theories of the formation of spiral arms.



The 21-cm. line profile (solid curve) in the direction of the Pleiades is double-peaked, as if it were a composite of the two dashed curves. The arrow marks the optically measured radial velocity of the cluster, and the vertical lines show radial velocities from interstellar lines in the spectra of stars in the cluster. Harvard Observatory diagram.

The other cluster observed by him is NGC 2264, which is presumably about 600 parsecs distant. In its direction are two condensations of neutral hydrogen, with the cluster at the farther edge of the near one. A dark cloud is known to lie immediately behind the cluster, and the radio observations show it to be of low neutral hydrogen intensity, over an area about six degrees in extent. H. C. van de Hulst and others have suggested that the formation of H_2 molecules might produce just such an apparent decrease in neutral hydrogen atoms. Perhaps the processes of condensation and molecule formation have proceeded to a considerable extent in the dark nebula beyond NGC 2264. A large number of T Tauri stars have been found by G. H. Herbig in this region. Mr. Menon said that it was tempting to relate the exhaustion of neutral hydrogen with the formation of the very young T Tauri stars.

ARTIFICIAL SATELLITES FOR METEOROLOGY

Uses of man-made satellites for weather studies were discussed in five papers at the New York meetings of the American Meteorological Society in January. Hilde Kallmann and W. W. Kellogg, of the Rand Corporation, listed possible observations of great importance to upper-atmosphere investigations, some obtainable only from a satellite. These problems include measurements of the earth's albedo, solar ultraviolet and X-ray radiation, and upper-air densities. Their discussion also considered altitude control, sensing devices, and telemetering.

Other papers dealt specifically with the advantages of the satellite for studying global weather conditions. For this, H. Wexler, of the U. S. Weather Bureau, recommended a vehicle in a four-hour, pole-to-pole orbit, some 4,000 miles above the earth's surface. From that height, the field of view corresponds in size to the present synoptic weather chart of North America and adjacent ocean areas. The pole-to-pole orbit would permit storm detection and tracking over the entire earth.

The same speaker stated that it was desirable to employ such a satellite for measurements of the earth's infrared radiation. This information would be of basic importance in studying the energy budget of the atmosphere and long-term trends in climate.

S. M. Greenfield, also of the Rand Corporation, pointed out that measurements of ordinary weather data (lower-atmosphere pressures, temperatures, and wind velocities) would not be possible from a satellite. Instead, weather reconnaissance would have to depend primarily upon cloud observations. From photographs secured on previous rocket flights, he has evaluated the feasibility of analyzing clouds for the determination of the synoptic picture.

Wolf-Rayet Stars

OTTO STRUVE

Leuschner Observatory
University of California

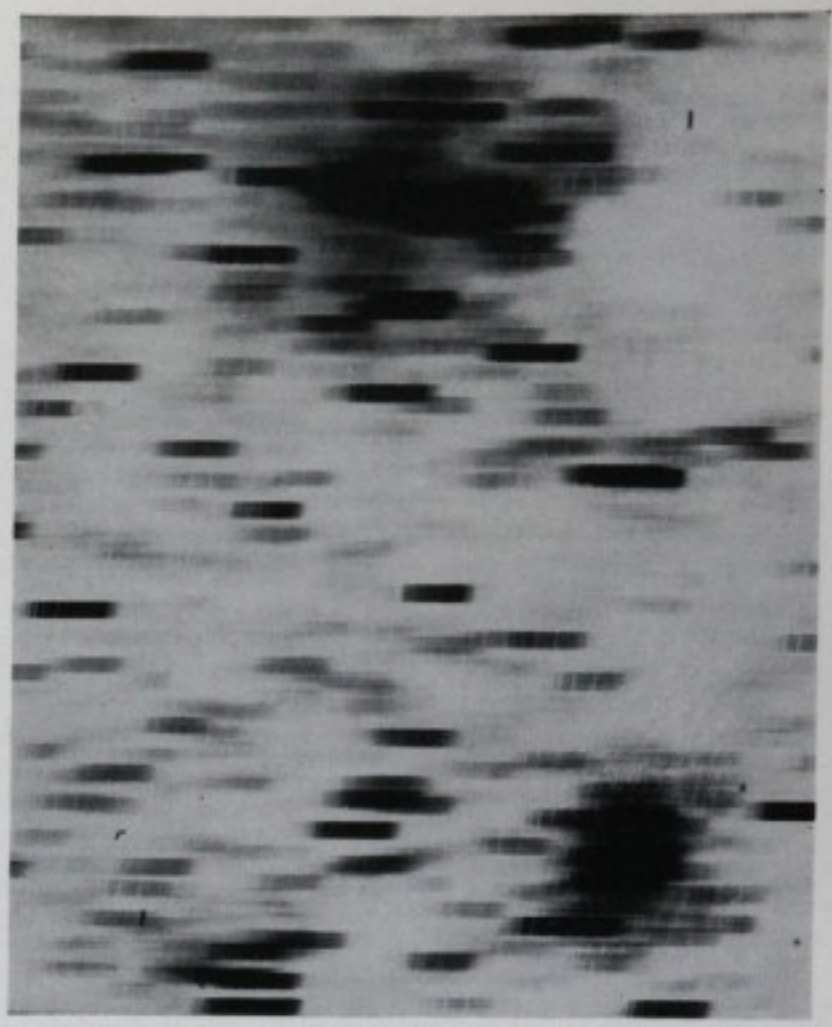


Fig. 1. Two stars of the Wolf-Rayet type are easily recognized in this objective-prism spectrogram from the Harvard Observatory collection. This is a negative print, on which the strong emission bands of the W stars appear as short dark lines. One such band is seen in the upper right. The other, in the lower left, is superimposed upon the continuous spectrum of the W star.

IN 1867 three stars with very unusual spectra were discovered at the Paris Observatory by C. Wolf and G. Rayet with a visual spectroscope. These stars, all in the Cygnus star cloud, are now usually known by their numbers in the *Henry Draper Catalogue* as HD 191765, HD 192103, and HD 192641. Their spectra showed numerous broad bright bands, superimposed on a faint continuous background.

Four years later, L. Respighi found that the 2nd-magnitude southern star γ^2 Velorum had a similar spectrum. Since that time, about 200 more Wolf-Rayet stars have been discovered. In the Henry Draper classification, they were designated, together with related very hot dark-line stars, by the letter *O* (Fig. 1). More recently it has become common to refer to the former as *W* stars.

The outstanding spectroscopic features of Wolf-Rayet stars are emission lines or bands, of atomic origin, which are often 60 to 100 angstroms wide, and sometimes 10 to 20 times brighter than the continuous spectrum adjoining them. In some cases, these emission bands are accompanied by rather weak and diffuse absorption lines on their violet edges. Most of the bright bands have been identified by Cecilia H. Payne and by B. Edlén as due to highly ionized atoms of helium, nitrogen, oxygen, silicon, and carbon. Neutral helium is present, but the lines of hydrogen are surprisingly weak.

Wolf-Rayet spectra, it was found by Miss Payne and by C. S. Beals, fall into two parallel sequences. Both contain hydrogen and helium, but one group, the *WC* stars, has strong lines of carbon; the other, known as *WN*, has strong nitrogen lines.

The *W* stars must be remote objects of high intrinsic luminosity. The best information on their distances is afforded by those Wolf-Rayet stars that occur in such stellar systems as the Large Magellanic Cloud or in star clusters whose distances are already known. On this basis, Henry Smith at Harvard Observatory concluded in 1955 that their absolute magnitudes range from −4 to −8, averaging −5, which makes these stars about 10,000 times as luminous as the sun.

These intrinsically bright stars are also among the hottest known. Several astronomers have applied the famous method of H. Zanstra, which consists in computing how many quanta of far-ultraviolet light such a star must emit to stimulate the observed intensities of its various emission features. From this can be found the temperature of the star's photosphere. The results for Wolf-Rayet stars come out about 60,000° to 100,000°. These high temperatures were confirmed by L. H. Aller, who obtained a value of about 50,000°, from spectral lines of the same element whose intensities are unequally sensitive to temperature effects.

If the absolute magnitude and temperature of a star are known, we can compute its size. In this way, Beals found that *W* stars, on the average, have twice the radius of the sun.

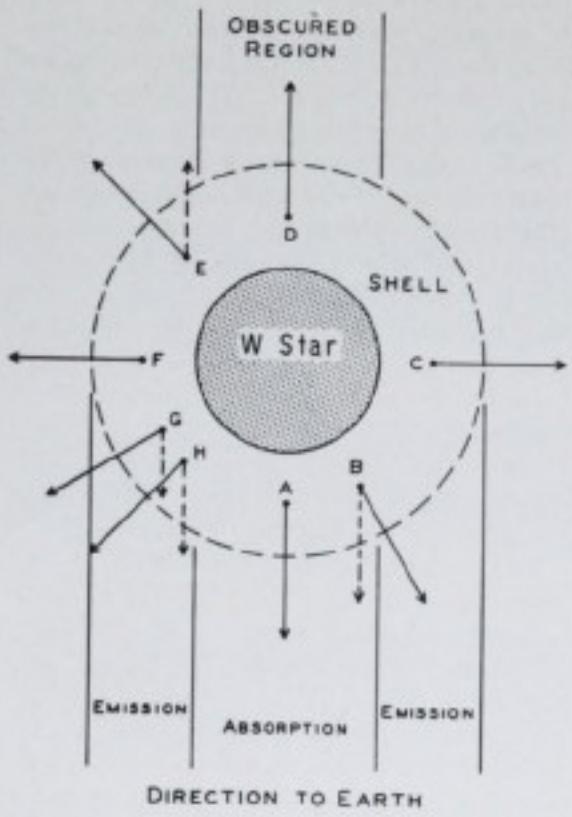


Fig. 2. An expanding shell of gas surrounding a Wolf-Rayet star accounts for the star's characteristic spectral features – broad emission bands flanked by absorption lines of shorter wave length–as explained in the text.

Beals was the first to advance strong reasons for interpreting the emission bands as due to an expanding shell of gas that surrounds the star. Most of the usual causes of line broadening are incapable of explaining the great width of the emission bands, which in some cases corresponds to a range of 3,000 kilometers per second in velocity along the line of sight. But the hypothesis of radial expansion is most strongly supported by the absorption lines at the violet edges of the bright bands. Both this effect and the emission line broadening are illustrated in Fig. 2, where we assume that an observer on earth looks upward toward the *W* star around which the envelope is expanding.

The dark lines, produced by the shell's absorption of starlight passing through such points as A and B, have a large Doppler shift to the violet because these points are approaching us rapidly. The red component of the absorption is missing, because points beyond the star, such as D, are obscured, where the recession of the envelope is greatest.

In the emission regions of the shell, on either side of the star, there is no

line-of-sight motion relative to the star for points C and F. But such points as E have a large component of recession, while G and H have velocities of approach; the emission line is broadened by the considerable range in line-of-sight velocities between E and H.

There is also a general similarity between the spectra of Wolf-Rayet stars and the novae, where expansion of nebulous matter has actually been observed.

A surprisingly large proportion of the Wolf-Rayet objects are spectroscopic binaries, and a few are also known to be eclipsing variables. There is a strong suspicion that each *W* star is one component of a close double star system. The other component—actually more massive but spectroscopically less prominent—is usually a dark-line *O*-type star. (It seems almost that the extraordinary spectroscopic appearance of a *W* star may be due to the presence in its immediate vicinity of a very hot, very massive, companion.)

The best known of these binary systems are V444 Cygni and CQ Cephei, but there are several other equally remarkable pairs. Recently, J. Sahade at Cordoba Observatory has found that γ^2 Velorum is itself a spectroscopic binary with a period of about 15 days.

The amount of information that has been accumulated on these stars during the past 15 years is very impressive. At a recent colloquium at Berkeley, Sahade summarized his own conclusions and those of previous investigators. In the

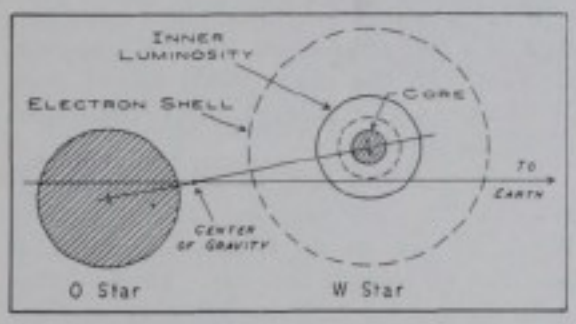


Fig. 3. This diagram illustrates a model for the system of V444 Cygni by G. E. Kron and Katherine C. Gordon, of Lick Observatory. Here the orbital positions are such that the W star and its envelope are eclipsing the O star, as seen from the earth. Adapted from the "Astrophysical Journal."

case of V444 Cygni, it was first indicated by the observations of S. Gaposchkin that the secondary eclipse has twice the duration of the primary eclipse. This must mean that the *W* star, which is in front during secondary eclipse, is surrounded by a semiopaque shell, probably of highly ionized gas. The light of the *O* star, when seen through this envelope, is dimmed by the scattering of light by free electrons (Fig. 3). But since the surface brightness of the envelope is negligibly small, at primary eclipse the total light diminishes appreciably only when the *O* star eclipses the *W* star itself, not its envelope.

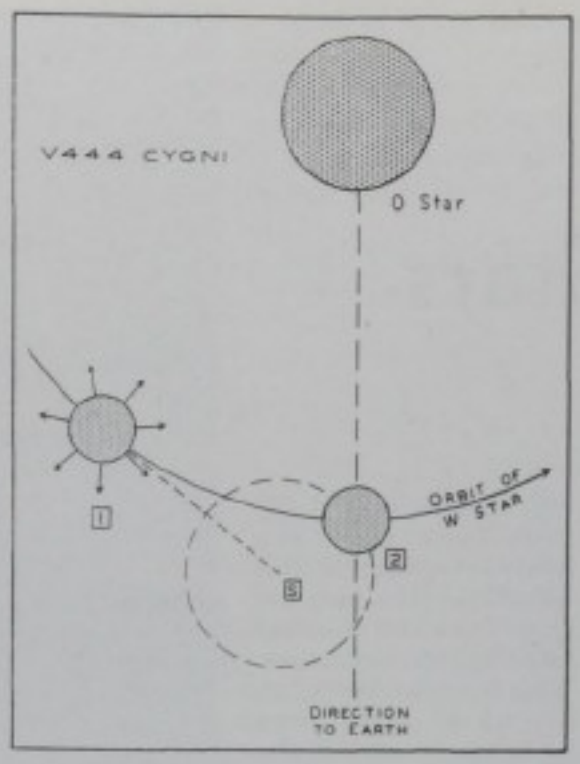


Fig. 4. This diagram of V444 Cygni illustrates O. C. Wilson's argument, given in the text, that the emission bands originate in the inner part of the shell surrounding the W star.

From the more recent work of Kron and Gordon, we know that the centers of the components of V444 Cygni are 27 million kilometers apart. The radius of the *O* star is about five million kilometers, and the *W* star is 0.45 as great, or three times the radius of the sun. (This is consistent with Beals' average result of twice the solar radius.) The electron envelope of the *W* star has 3.8 times its radius, making it 12 times the dimensions of the sun, as indicated in Fig. 3.

The shell is thus not very large compared with those of other types of stars. It certainly belongs to the Wolf-Rayet star, because the broad emission bands show Doppler shifts that indicate the motion of that component, and not of the *O* star. There are some reasons for believing that these emission features are produced mostly in the innermost strata of the envelope. Since there are no forbidden spectral lines, the gas cannot be very far from the source of the radiation that excites it. Also, O. C. Wilson has called attention to the absence of a difference between the time of mid-eclipse as observed from the light variation, and as inferred from the radial velocity curve of the broad emission bands. The signficance of this is explained in Fig. 4.

Atoms expelled from the *W* star move outward at some 1,000 kilometers per second, so fast that their paths are virtually unchanged by the attraction of the *O* star. The atoms that leave the *W* star when it is at position 1 in Fig. 4 form a shell centered at S by the time the *W* star reaches position 2. At this moment, when the *W* star is directly in front of the *O* star, the shell has not yet become lined up with the latter. Therefore, the time of mid-eclipse, as observed by the minimum of light intensity, should occur earlier than as deduced from observations of the emission lines produced in the shell. The larger the shell, the longer this time lag would be. Actually, however, for V444 Cygni the time lag is too short to observe. Thus, the shell in which the emission arises must be very little larger than the *W* star itself.

Although the widths of the emission bands imply large velocities of expansion, these do not normally exceed the velocity of escape from the binary system, or even from the gravitational field of the *W* star itself. Thus, we can consider V444 Cygni in terms of the zero-velocity surfaces, which were explained on page 65 of the December, 1955, issue. Fig. 5 is based on Sahade's ideas. It shows the two stars and the gaseous shell within the framework of the zero-velocity surfaces. Each of these represents how far material can rise if ejected with a particular velocity from the star.

The shell certainly overflows the outermost of the loops surrounding the *W* star; such material cannot permanently belong to this star but must stream around the system as a whole. It is not surprising that Sahade and others have found evidence of another, very large absorbing shell, surrounding the entire system and expanding in all directions. In the spectrum of γ^2 Velorum, this outer shell produces the relatively narrow absorption line of helium at 3888 angstroms. The structure and intensity of this line vary (Fig. 6), probably in an irregular manner. Even during the single night of February 28, 1950, Sahade found a marked change in the character of this multiple line. The average displacement of the line corresponds, at all phases, to a velocity of approach of 1,300 kilometers per second.

The latest spectrographic study of V444 Cygni was by G. Münch, at the McDonald Observatory in 1950. He obtained the spectrum shown in Fig. 7 and the velocity curves in Fig. 8. He established that the free electrons in the shell

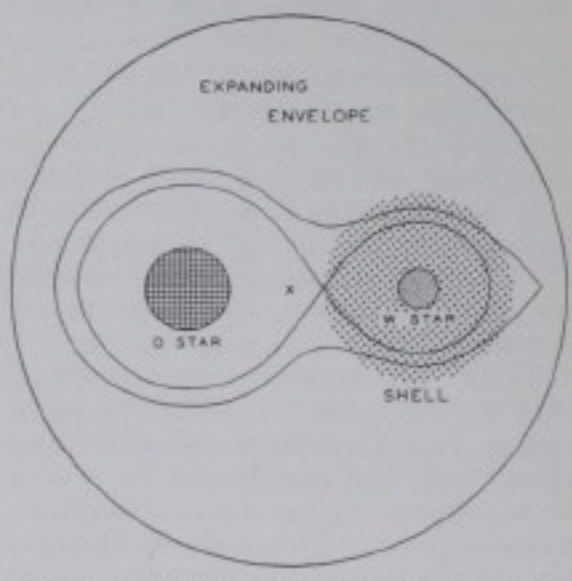


Fig. 5. In this schematic diagram of the zero-velocity surfaces of V444 Cygni, the system's center of gravity is marked by a cross.

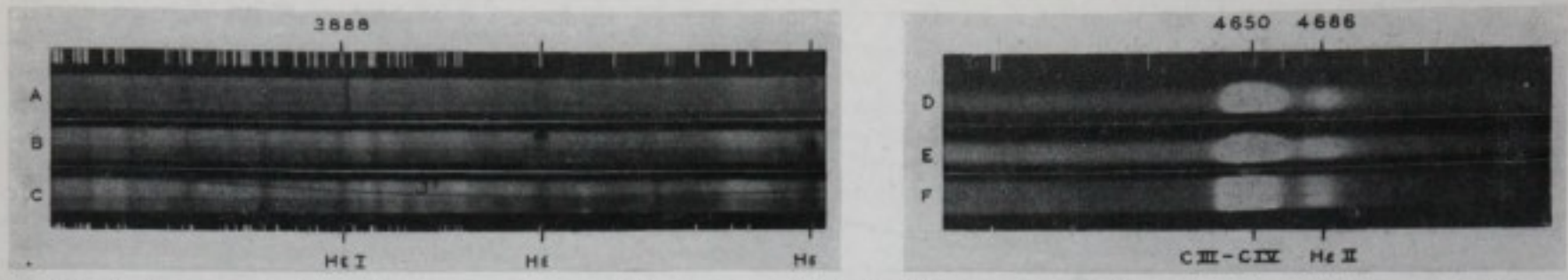


Fig. 6. Spectra of the southern star Gamma Velorum, secured by J. Sahade, of Cordoba Observatory. The three at the left, A, B, and C, were taken in 1950, on February 4.18, 28.08, and 28.25, respectively; they illustrate the striking changes in the neutral helium line at 3888 angstroms. The hydrogen-epsilon and hydrogen-delta lines also appear. Spectra D, E, and F were taken in 1950, on December 15.25, 17.13, and 21.22, respectively; they show broad emission bands of ionized helium and of doubly and triply ionized carbon.

surrounding the *W* star do more than merely weaken the light of the *O* star; they also broaden considerably the absorption lines of this star and broaden the emission bands formed in the inner parts of the *W* star's shell.

Sahade asks whether the *O* component may not also be surrounded by an extensive ionized shell, so that it too overflows the outer zero-velocity loop. In this shell, if it exists, free electrons are probably much scarcer than in the *W* star's shell, for the broad emission bands are not weakened during secondary eclipse. There are some strange asymmetries in the emission bands, opposite in character at the two eclipses. Perhaps they can be explained by a shell around the *O* star.

For the Wolf-Rayet binary CQ Cephei, W. A. Hiltner obtained a remarkable and as yet unexplained spectroscopic result: The emission band of ionized helium at 4686 angstroms is intrinsically strongest at the two eclipses. The period of orbital motion of CQ Cephei is 1.6 days.

"If," writes Hiltner in the *Astrophysical Journal*, "the emission had its origin in a compact shell about the parent-star, then we should have observed a light-curve with only one minimum. Likewise, if the emission had its origin in a shell large relative to the parent-star, then we should have expected a more or less constant intensity of *He* II 4686. However, neither is the case, for the emission is more intense at conjunctions than at quadratures. . . . [The] model must be such that the amount of observed emitting material is greater at the advancing and receding hemispheres of the Wolf-Rayet component."

If all *W* stars are members of close binaries, then those with constant radial velocities must have their orbital planes nearly at right angles to the line of sight, that is, almost in the plane of the sky. As far as we know, the emission bands of these stars are just as broad as in the eclipsing systems, where the orbits lie nearly in the line of sight. Consequently, the emitting shells are not flat, or nearly

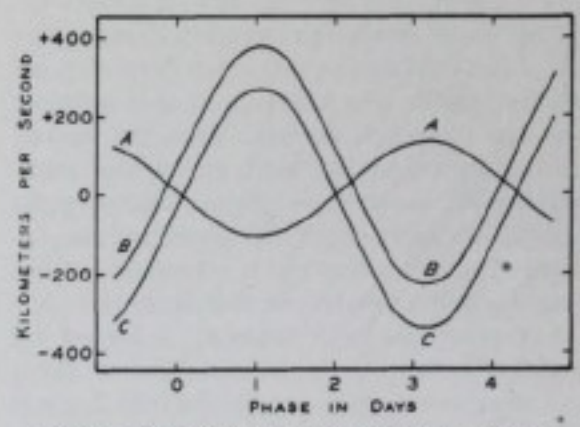


Fig. 8. In these radial-velocity curves of V444 Cygni, curve A represents the orbital motion of the O star. B and C refer to the shell of the W star, as indicated by lines of nitrogen ionized four and three times, respectively.

flat; they must be essentially spherical in shape, and the pattern of motions in the shell must be the same in the orbital plane and at right angles to it.

In this respect, the Wolf-Rayet objects differ strikingly from the rapidly rotating *B*-type stars with ringlike shells, such as

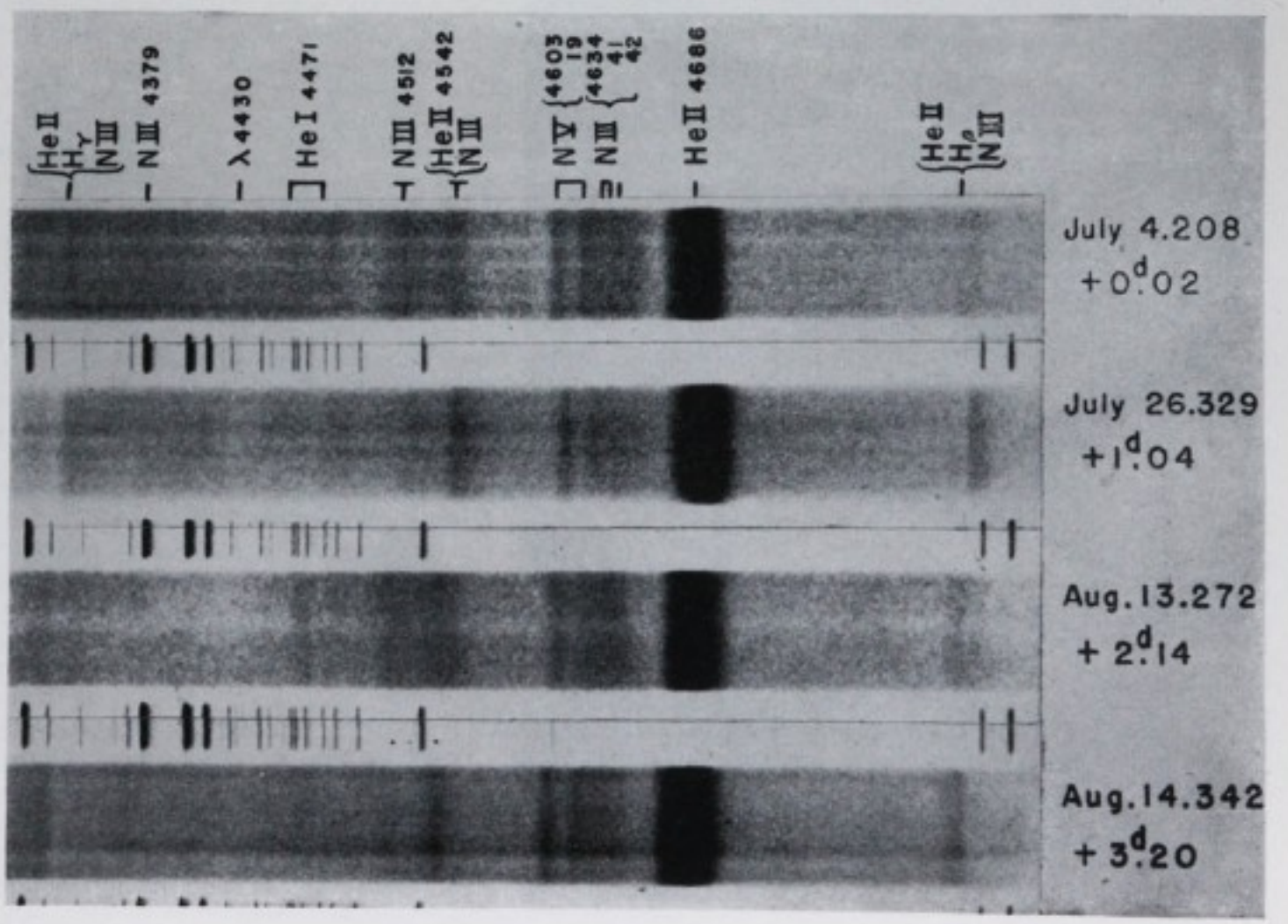


Fig. 7. These spectra of V444 Cygni are among a series of 93 obtained by G. Munch and O. Struve at the McDonald Observatory between July 4th and August 15th, in 1949. On these negative reproductions, the emission lines and bands appear dark. The Doppler effect causes perceptible wavelength shifts of the spectral features during the course of the 4.21-day cycle of orbital motion. The engraving has been lent by the editor of the "Astrophysical Journal."

Pleione (see *Sky and Telescope*, August, 1952, page 243) and 48 Librae. But it is suggestive that in 48 Librae the extreme wings of the hydrogen-alpha emission line correspond to velocities of +700 and −700 kilometers per second—far greater than can be explained by a simple gaseous ring revolving around the star in its equatorial plane. Anne B. Underhill has suggested that the great width of this line may be partly due to chaotic motions of the material emitting the line. One might guess that this material is located in the innermost layers of the shell of 48 Librae.

Perhaps in a similar manner much of the broadening of the emission lines in Wolf-Rayet stars is due to chaotic motions, rather than to a systematic outflow of gas. As we have seen, violet absorption borders without their red counterparts indicate there must be *some* outflow, but strong violet borders are the exception rather than the rule.

A Tribute to Robert Frost

PERCY M. PROCTOR, *Babylon High School, Babylon, New York*

ONE of America's greatest living poets is celebrating his 81st birthday on March 26th. No other poet that I know of has matched Robert Frost in saying so many things so well about the stars. In nearly a score of poems that express his deep interest in the heavens, his inspired words point out a significance that only a poet would see and interpret.

A year ago in November, I stayed up with two friends from midnight to three in the morning to watch for the Leonid meteor shower. We recalled these lines that Frost had written:

From following walls I never lift
an eye
Except at night to places in the
sky
Where showers of charted meteors let fly.

At dusk the other evening, I stayed outdoors to watch Venus in the western sky, then came in to read again Frost's poem, "The Literate Farmer and the Planet Venus," in which long ago I underlined these words:

To see it so, the bright and only
one
In sunset light, you'd think it
was the sun
That hadn't sunk the way it
should have sunk,
But right in heaven was slowly
being shrunk
So small as to be virtually gone,
Yet there to watch the darkness
coming on—
Like someone dead permitted
to exist
Enough to see if he was greatly
missed.

When I go out at night to locate some obscure constellation and find myself defeated in tracing out its stars because the street lights offer so much competition, I think how aptly Frost has said:

A town debars
Much notice of what's going on
in stars.

Best of all, I like "The Star Splitter," the story of Brad McLaughlin, the New Hampshire farmer who burned his farmhouse to collect insurance so he could buy a telescope, because he believed,

The best thing that we're put
here for's to see;
The strongest thing that's given
us to see with's
A telescope. Some one in each
town
Seems to me owes it to the town
to keep one.

In that poem Frost tells how he and Brad spent evenings at the telescope looking up at a "star quaking at the other end" and said "some of the best things we ever said."

Also in "The Star Splitter," in its opening lines we read,

You know Orion always comes
up sideways.
Throwing a leg up over our fence
of mountains,
And rising on his hands, he looks
in on me
Busy outdoors by lantern-light
with something
I should have done by daylight.

There are a dozen more Frost poems with special appeal to the stargazer, among them "Canis Major," "Fire and Ice," "Fireflies in the Garden," "On Making Certain Anything Has Happened," and "Skeptic." In another, we are asked to "choose something like a star, the fairest one in sight," to be a guide to the highest things of life:

So when at times the mob is
swayed
To carry praise or blame too far,
We may choose something like
a star
To stay our minds on and be
staid.

This humble stargazer is thankful to Robert Frost for his interest in the great starry host of the heavens.

This is a reproduction of a painting by the late D. Owen Stephens. Entitled "The Astronomer," it contains representations of the many different kinds of celestial bodies that form the realm of astronomy. American Museum of Natural History photograph.

☆ ☆ *SKY AND TEACHER* ☆ ☆

Sponsored by the
Teachers' Committee of the American Astronomical Society

A WORKSHOP IN THE TEACHING OF ASTRONOMY – I

THE FIRST WORKSHOP in the teaching of astronomy was offered by the writer in the 1955 summer session at Cornell University. It was intended primarily for secondary school teachers but was open also to teachers of elementary astronomy in colleges and normal schools as well as leaders of civic groups. The program was the culmination of experimentation, over a period of years, with lecture and laboratory work directed toward the development of effective teacher training in astronomy.

The objective was to enable teachers, not professionally trained as astronomers, to acquire a limited but sound astronomical knowledge—as well as those tools, techniques, and methods by which they might create and sustain in their own students an appreciation of the intellectual and practical problems arising from man's conquest of space.

The workshop was divided into four interrelated programs, two of which we shall consider now and two that will form the subject of this column in May:

1. Curriculum content for high school, college, and civic groups.
2. Review of subject matter pertinent to these curriculums, with emphasis on teaching techniques.
3. Teaching aids: methods and materials for demonstration, model construction, group projects, celestial observations, and sources of supply.
4. Construction in the department optical shop of a 6-inch mirror for a personal telescope.

Curriculum Content

It is evident from a cursory examination of general science texts that no general agreement exists concerning the educational objectives of the astronomical unit. Both content and extent of treatment appear to depend on whims of authors. Moreover, there are few if any state requirements at present, and those that do exist relate chiefly to the subjects of latitude, longitude, time, and the tides.

In view of this situation and in the interests of purposeful instruction, there were developed with the teachers of the workshop definite curriculums appropriate for the 7th, 8th, and 9th grades. Variations of these suggestions were then considered for civic groups and several types of college classes. Space does not permit detailed descriptions of these curriculums.

In the first part of the course, somewhat to the surprise of the writer, while the teachers appreciated help in the matter of curriculum content, they cared little for a part in setting up the requirements. They preferred simply to have a curriculum proposed, with the decision as to whether or not they could carry it out left entirely to them. Perhaps this reaction stems from inexperience and lack of knowledge of the subject. Characteristically, secondary teachers seem to want and need, probably because their days are crowded with classes and activities, practical and definite suggestions on what to do and how to do it, without much philosophical embellishment.

Introductory topics should be those for which a reasonably direct appeal to student experience can be made. Selection of topics and their discussion in successive grades must show clear evidence of progression, since at these levels students are prone to scorn repetition as "old stuff" regardless of how little they may actually know. There should be appropriate coverage for those not going beyond high school; at the same time, interest should be aroused and a firm foundation assured for those who plan a college career. This dual objective, while not easy to attain, is basic if effort is to be conserved in the critical 8th and 9th grades.

As a goal toward which the several curriculums might lead, the subject matter of a year course in college astronomy (Baker or Duncan texts) was critically reviewed. From the mass of detail treated therein, certain topics were considered basic for step-by-step amplification at the lower grades. Included were the solar system, stars and constellations, the galaxy, external galaxies, instruments, and time and position. Treatment would range, for example, from brief mention of external galaxies in the 7th grade to problems of types and distances in the 9th.

At each level the teacher was urged to bring the student repeatedly into contact with celestial phenomena through visits to observatories and planetariums, and by class observations or planned homework. It was generally agreed that personal contact with celestial phenomena, while not vital to lasting interest in astronomy, is certainly conducive to its growth. Unfortunately, such contacts are not always easy to establish.

Also, an early introduction to the study of light by the spectroscope was advocated. Spectroscopy currently receives rather haphazard treatment in general science texts. Actually, the subject lends itself beautifully to demonstration in lecture and laboratory, and possesses a high interest rating in view of its relation to atomic structure. Throughout the workshop, every opportunity was grasped to illustrate the importance of spectroscopy to astronomy in particular and to science generally.

Review of Subject Matter

Most of the members of the workshop had previously taken a short course in college astronomy, and the few not thus prepared were simultaneously registered in a course in descriptive astronomy. This fortunate circumstance made possible a review of subject matter on a somewhat higher level than expected, and more time was available for emphasis on teaching techniques as the review progressed.

The vividly written *Design of the Universe*, by Fritz Kahn, was chosen as a text. As is well known, this book is not devoted exclusively to astronomy, but portrays in sweeping terms the entire span of the known universe, with astronomy placed in proper relation to the other physical sciences. The result is admittedly controversial, but stimulating. Astronomy in the secondary school is generally taught as part of general or earth science and is not compartmentalized as completely as in colleges and universities. Kahn's book served therefore as a kind of super general science text, and as such was enthusiastically received. Methods of presentation used in this book served as stimulating bases for discussion as to applicability in the grades. All of the teachers agreed that the book would serve well as a reference for their own students.

This subject matter review could be removed, of course, from the workshop and treated more or less as a standard introductory astronomy course. Admittedly the workshop progressed on a higher level for those students who possessed some astronomical background than for those with none. However, experience shows that methods of teaching should be tied directly to a fresh and active appreciation of subject matter.

Kahn's book holds attention and interest through a vivid and striking treatment of astronomical observation and theory. Nevertheless, there are too many places where one feels strongly the need for more details or more complete explanations. It seems that the ideal book for the workshop would be one written on the block-and-gap method with subject matter treated in greater detail than that generally found in introductory texts.

Since teachers are continually pressed by questions of how and why, the methods by which results are achieved should be amply described and illustrated. Limitations to our knowledge and interpretations should be clearly stated. Herein would lie the road to lively class discussions and the stimulation of mental curiosity so needed in our science teaching programs. Obviously, the expert needs no such aid, but we cannot in all fairness expect every science teacher to be an expert in every field.

R. WILLIAM SHAW, chairman
Department of Astronomy
Cornell University

Amateur Astronomers

The planetarium and observing station of Richard H. Emmons.

The North Canton Planetarium in Ohio

ESTABLISHMENT of small planetariums, widely distributed, to serve elementary and secondary school children, is advocated by Richard H. Emmons, a flight-test engineer who in his spare time operates a planetarium situated behind his home at 313 Donner Rd., North Canton, Ohio.

This venture began as a small home installation, and has expanded into a full-scale operation. In August, 1955, Mr. Emmons completed a one-story building containing a 14-foot fabric dome, under which 36 persons may be seated. The North Canton Planetarium is light-proofed for daytime demonstrations, double-walled and insulated, with forced-air ventilation and gas heat. The equipment includes the home-made star projector, auxiliary projectors for the planets and other objects, a tape recorder, and several telescopes, which are used to supplement planetarium shows when observing is good.

Regular evening performances are held, as well as daytime sessions for school children in the Canton area. In Mr. Emmons' absence at work, his wife operates the projector with the aid of a tape recording of the planetarium talk. Over 1,000 persons attended the fall and winter programs, on autumn stars and the Star of Bethlehem, respectively. In addition, Mr. Emmons conducts a regular astronomy class, in which he has had such features as a recorded interview with Homer Newell, Jr., on the International Geophysical Year and the artificial satellite project, low-power views of the Orion nebula and the Double Cluster in Perseus, and a discussion on cosmic rays.

A former instructor of astronomy at Kent State College, Mr. Emmons has been on the staff of the Morehead Planetarium at the University of North Carolina. He wrote his master's thesis on the construction of a school planetarium, and has sponsored several astronomy clubs.

The planetarium is located in the Stark County area a few miles from Canton, and a fee is charged for the demonstrations. Interested persons may contact Mr. Emmons for individual and group showings.

HARRISBURG, PA.

On February 7th, last year, a notice in local newspapers announced a meeting for those interested in astronomy, at the Harrisburg, Pa., YMCA. That night, some 35 persons crowded the small meeting room and the Harrisburg Astronomical Society was organized.

The society now has 40 active members and 12 telescopes ranging from an 8-power instrument to a 6-inch reflector and a 4-inch refractor. The group holds regular star parties, monthly lectures, lens-grinding sessions, and an occasional field trip to nearby planetariums and observatories, such as at Franklin and Marshall College in Lancaster, Pa.

Persons who wish to join the society may contact Edward L. Naylor, of 320 Wilhelm Rd. The society is a member of the Astronomical League.

PLANETARIUM AT FRANKLIN AND MARSHALL COLLEGE

During its operation for the past two years, the planetarium of Franklin and Marshall College, Lancaster, Pa., has had an average annual attendance of nearly 20,000 visitors. The planetarium is located in the North Museum and is operated by a volunteer staff. It is housed in a dome 41 feet in diameter, with a Spitz instrument and special optics. Programs are presented at 8 p.m. on Tuesdays and Thursdays, at 3 p.m. on Saturdays and Sundays, and at other times by appointment. There is no admission charge.

Each clear Friday evening as well, the Scholl Observatory holds open nights, using its 11-inch refracting telescope. The observatory is also located on the campus.

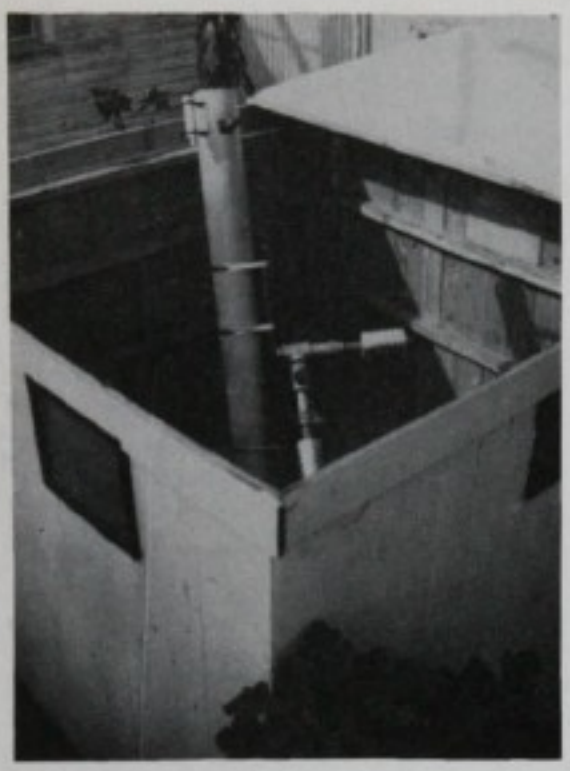
HOWARD L. FEATHER
615 State St.
Lancaster, Pa.

PAPERS ASKED FOR MIAMI CONVENTION

Amateurs who would like to report on their astronomical activities at the Astronomical League convention in Miami, Fla., July 2-5, are invited to submit a tentative title of each paper and a brief description of its contents. The program chairman is Arthur P. Smith, Jr., 426 S. W. 26th Rd., Miami 36, Fla.

Early response, by March 15th if possible, is necessary since the time on the program is expected to be allotted soon.

This is a composite picture from two negatives. A 10-minute exposure was used to record the stars, then the lens was stopped down and a flash was used to photograph Mr. Emmons and the projection instrument. Since this picture was taken, a silhouette skyline has been added by Mr. Emmons' 13-year-old daughter. Photograph by Richard Bixler.



John Gunther's observatory has a roll-off roof, opened here to show his prize-winning telescope.

GRETNA, LA.

The observatory illustrated here is the creation of John Gunther, 209 Newton St., Gretna, La., a high school junior. He is also president of the Gretna Astronomical Society.

The main telescope, a 6-inch f/12.5 Newtonian reflector, was constructed by Mr. Gunther and was awarded first place among 53 exhibits at the New Orleans Junior Academy of Sciences, Tulane University. The mounting is a German-type equatorial and has poured babbitt bearings on both axes. There is a 15-degree wedge placed under the 45-degree mounting elbow to give the elevation of the polar axis required by the latitude of 30° north.

Constructed with the aid of Ronald and Richard Guthrie, the observatory has a roll-off roof. The observing floor is eight feet square. To avoid vibration, the telescope pier is isolated from the building itself. Other equipment in the observatory includes a 2.4-inch altazimuth refractor.

Persons in the Gretna area interested in inspecting the observatory or desirous of joining the society may contact Mr. Gunther at the above address.

EAST CLEVELAND, OHIO

A series of open nights for the public is being held at the Warner and Swasey Observatory, Taylor Rd., East Cleveland, Ohio. The lectures begin at 8 p.m.

Topics for March 22nd and 23rd will be "The Smallest Stars Known"; for April 19th and 20th, "Space Travel, Man's Greatest Adventure"; and for May 24th and 25th, "Stars that Vary in Brightness."

For reservations, call the Warner and Swasey Observatory, GLenville 1-5625, after 1:00 p.m.

HOUSTON, TEX.

On Sept. 16, 1955, 71 persons organized the Houston Amateur Astronomy Club, electing W. W. Myers president and S. M. Black secretary-treasurer. The club holds regular meetings on the first Friday of each month at the Museum of Natural History in Herman Park.

Among the instruments used at star parties is a 20-inch telescope, mounted on a truck, and owned by Mr. Myers. Several members have a number of smaller telescopes.

Information about the group may be had from Mr. Myers, 7424 Tipps St., Houston 23, Tex.

A JUNIOR'S TELESCOPE

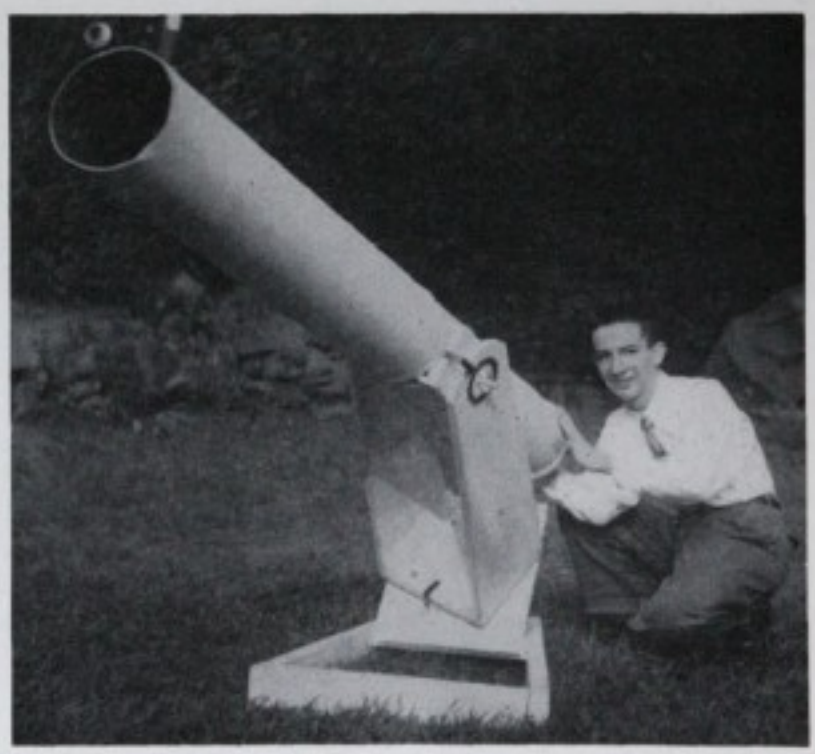
PROCURING a telescope on an allowance of one dollar a week is, to say the least, a difficult matter. However, by poring over the pages of *Sky and Telescope* and walking the streets to the optical companies, I finally constructed a satisfactory instrument at a cost of $60.75.

The principal expenses were $19.00 for a commercially made 6-inch mirror kit, which included a diagonal flat and materials to construct a 150x eyepiece, $10.00 for a rack-and-pinion assembly, and $16.50 for an Erfle eyepiece.

The telescope tube is of reinforced cardboard, painted and shellacked for protection from moisture. Its wooden equatorial mounting is similar in design to that of Joseph A. Raab, Jr., pictured on page 169 of the March, 1954, issue. Aluminum was my first choice, but wood was cheaper. I began work in April, 1955, and completed the instrument in July. I plan later to construct a clock drive, to permit celestial photography.

Due to the long focus of the telescope, planetary work is its forte. Markings on Saturn have been clearly seen with 200x, and glimpses through 270x proved quite satisfactory. I plan extensive study of Mars this summer. But my observing experience is limited, and I would like to correspond with other junior observers. I am 13 years old, and a member of the Junior Astronomy Club, which has its headquarters in Brooklyn. I contemplate eventually becoming a professional astronomer.

STEPHEN E. STROM
1950 Andrews Ave.
New York 53, N. Y.



An easy-to-build wooden mounting carries Stephen Strom's 6-inch reflector.

The Frustrated Astronomer

Whenever I'm stargazing out in the night
Not one thing I do seems to turn out all right.

I set up my 'scope and toward galaxies gaze—
There's nothing to see through the leaf-smoke and haze.

The planets, my goal on the following night,
Just cannot be seen past the neighbor's porch light.

Then meteor charting, with attitude grim—
The rising moon's light makes their trains far too dim.

The following night I am set for the moon,
But rain drops beat out their monotonous tune.

I've lost all my patience, I've lost all my hope;
From now on I'll stargaze in my Sky and 'Scope.

LARRY TEIEN

CORRECTION TO LUNAR MAP

The crater labeled No. 161 on the Lunar Map published in January is listed as Kunowsky, whereas it should be Landsberg C. Kunowsky is located at selenographic longitude −33°, latitude −3°.

THIS MONTH'S MEETINGS

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. Mar. 16, Dr. A. N. Vyssotsky, Leander McCormick Observatory, "Red Dwarfs and Their Motions."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Lone Star Gas Co. auditorium. Mar. 26, astronomical film.

Detroit, Mich.: Detroit Astronomical Society, 2:30 p.m., State Hall, Wayne University. Mar. 11, Dr. Everett R. Phelps, "The Solar System."

Geneva, Ill.: Fox Valley Astronomical Society, 8 p.m., City Hall. Mar. 13, Prof. Clarence R. Smith, "American Observatories."

Long Beach, Calif.: Excelsior Telescope Club, 8 p.m., home of Dick Norton, 3157 Chatwin Ave. Mar. 16, Jim Daugherty, "Aluminizing Mirrors."

Lorain-Elyria, Ohio: Black River Astronomical Society, 8 p.m., Elyria YWCA. Mar. 21, Arthur Goldstein, "Stellar Evolution."

Los Angeles, Calif.: Los Angeles Astronomical Society, 7:45 p.m., Griffith Observatory. Mar. 13, Dr. Margaret Burbidge, Cavendish Laboratory, Cambridge University, "The Origin of the Elements."

Montreal, Canada: Montreal Centre, Royal Astronomical Society of Canada, 8:15 p.m., Macdonald physics building, McGill University. Mar. 8, Alan Barnes, "The Stars." Mar. 22, Dr. Peter M. Millman, National Research Council, "The Solar Eclipse of June 30, 1954."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Mar. 7, symposium, "Life on Other Worlds."

HERE AND THERE WITH AMATEURS

*Members receive *Sky and Telescope* as a privilege of membership. †Member organizations of the Astronomical League.

State	City	Organization	Time	Meeting Place	Communicate With
ALABAMA	Birmingham	*Shades Valley A.C.	7:30, 3rd Tue.	Homewood Pub. Libr.	Mrs. Irvin M. Cox, 208 Dexter Ave. (9)
ARIZONA	Phoenix	*Phoenix Obs. Ass'n	8:00, 2nd, 4th Mon.	Phoenix Coll., homes	A. H. Hoff, 1102 W. Thomas Rd.
	Tucson	*Tucson A.A.	7:30, 1st Wed.	Steward Obs.	Mrs. Kathryn Burch, 216 Busch Pl.
ARKANSAS	Augusta	†*Augusta A.C.	7:30, Fri.	Private homes	J. W. Haralson, Box 296
	Little Rock	†*Arkansas A.A.C.	7:30, 3rd Mon.	Various places	C. P. Kulp, 1322 Donaghey Bldg.
CALIFORNIA	Bakersfield	Bakersfield A.A.	7:30, 1st Thu.	7-Up Bldg.	J. O. Davis, 400 S. Hill St., Arvin
	Bakersfield	†*Kern A.S.	7:30, Alt. Sun.	Youth Building	K. A. Thuloweit, 622 Wilson Ave., Oildale
	Fresno	*Central Val. Ast'mers	7:45, 2nd Mon.	Fresno Coll., homes	Elizabeth Dean, 3534 N. Callisch (3)
	Kentfield	*Marin Am. Ast.	8:00, 1st Mon.	Coll. of Marin	Rita Treleven, Box 102, Fairfax
	Long Beach	†*Excelsior Tel. Club	7:30, 3rd Fri.	Private homes	T. R. Cave, Jr., 265 Roswell Ave. (3)
	Los Angeles	L.A.A.S.	7:45, 2nd Tue.	Griffith Obs.	Miss H. Pearce, 1000 N. Seward, H'wood (38)
	Oakland	*Eastbay A.S.	8:00, 1st Sat.	Chabot Obs.	F. O. Groch, 2315 Eunice St., Berkeley (8)
	Oroville	Feather River A.C.	8:00, 2nd, 4th Tue.	Private homes	John T. Jensen, Rt. 4, Box 1732
	Palo Alto	*Peninsula A.S.	8:00, 1st Fri.	Community Center	H. W. Milner, 350 Tennyson Ave.
	Redlands	*Redlands A.S.	8:00, 4th Thu.	Univ. of Redlands	Miss R. Schweikert, 111 Prospect Dr.
	Sacramento	*Sac. Val. A.S.	8:00, 2nd Thu.	Calif. Jr. Mus.	Mrs. E. Champ, 3816 Sacramento Blvd. (17)
	Santa Barbara	S. B. Star Cluster	8:00, Last Tue.	Private homes	Capt. C. Adair, 607 Miramonte Dr.
	San Diego	Ast. Soc. of S.D.	7:30, 1st Wed.	504 Electric Bldg.	W. T. Skilling, 3140 Sixth Ave.
	San Diego	A.T.M. Ast. Club	7:30, 2nd, 4th Mon.	3121 Hawthorn St.	Al Nelson, 3121 Hawthorn St.
	San Francisco	*S.F. Am. Ast'mers	8:00, 1st Wed.	Randall Jr. Museum	H. A. Wallace, 2925-A Jackson St.
	San Jose	*S. J. Am. Ast'mers	8:00, 3rd Mon.	State Coll., Sci. Wing	T. J. Nelson, Jr., 822 W. Iowa, Sunnyvale
	Stockton	*Stockton A.S.	8:00, 2nd Mon.	Stockton Coll., C-3	W. D. Purdy, 325 E. Kettleman Lane, Lodi
	Whittier	†*Whittier A.A.A.	7:30, 1st Tue.	Bailey School	Gary A. McCue, P.O. Box 531
	Whittier	†Whittier A.S.	7:00, Alt. Sun.	Private homes	R. N. Sturtridge, 8416 Daviska Dr.
COLORADO	Boulder	*Boulder A.S.	7:30, 2nd Wed.	Sommers-Bausch Obs.	Vernon Goerke, 3045 Bluff St., HI 2-3447
	Denver	*Denver A.S.	8:00, 2nd, 4th Fri.	Chamberlin Obs.	R. A. Spencer, 1711 Washington Ave., Golden
	Pueblo	†*Pueblo A.S.	7:30, 1st Mon.	2421 2nd Ave.	Mrs. Marjorie Struthers, 2329 E. Routt Ave.
CONNECTICUT	Middletown	†*Central Conn. A.A.	8:00, 1st Tue.	Van Vleck Obs.	W. Fellows, RFD No. 1, Hill St., Glastonbury
	New Haven	†A.S. of New Haven	8:00, 4th Sat.	Sterling Tower	Florence Welter, 77 Spring Rd., N'th Haven
	Stamford	†Fairfield Co. A.S.	8:30, 3rd Fri.	Stamford Museum	Mrs. R. Best, Stamford Museum
	Stratford	†*Boothe Mem. A.S.	8:30, 4th Tue.	Boothe Mem. Park	A. Farian, 227 Spring, Bridgeport (8)
DIST. COL.	Washington	†*Nat'l. Cap. Ast'mers	8:00, 1st Sat.	Comm. Dept. Audit.	Mrs. G. Neville, 1549 N. 17th, Arlington, Va.
FLORIDA	Daytona Beach	D. B. Stargazers	8:00, Alt. Mon.	105 N. Halifax Ave.	Wm. T. Thomas, 105 N. Halifax
	Eau Gallie	†*Indian River A.S.	8:00, 2nd Wed.	City Hall	Mrs. Helen DePaolo, 1353 Everglade Dr.
	Jacksonville	†*J.A.A.C.	8:30, 1st, 3rd Mon.	Private homes	E. L. Rowland, Jr., 225 W. Ashley St. (2)
	Key West	†Key West A.C.	...., 2nd Mon.	Private homes	J. M. Martin, 1521 Duncan St.
	Miami	†*South'n Cross A.S.	8:15, 3rd Mon.	Junior Museum	A. P. Smith, Jr., 426 S. W. 26 Rd. (36)
	Miami Springs	†*Gulfstream A.A.	8:00, 4th Wed.	University of Miami	L. G. Pardue, 641 Falcon, TU 8-5434
	Orlando	*A.A.C. of Orlando	7:30, 2nd Thu.	Edgewater H.S.	Claude B. Green, 354 Mashie Lane
	Pensacola	†Pensacola A.A.C.	8:00, Wed.	Private homes	John Aguilar, 1203 N. 9 Ave.
	St. Petersburg	†St. P'burg A.A.C.	7:30, 4th Tue.	City Museum Audit.	Dr. R. E. Angell, 233 5th Ave. N.
GEORGIA	Atlanta	†*Atlanta A.C.	8:00, 3rd Fri.	Agnes Scott College	W. H. Close, 225 Forkner Dr., Decatur
	Columbus	*Columbus A.A.C.	7:30, 2nd Fri.	Bradley Mem. Lib.	Mrs. J. Jones, 2605 Cherokee Ave.
	Macon	†*Macon A.A.C.	Irregular	Private homes	Harvey W. Healey, 413 Rogers Ave.
HAWAII	Honolulu	Hawaii A.S.	7:30, 3rd Tue.	McKinley H.S., Cot. 36	R. Terry, 99-531 Kaholi Pl., Aiea, 463762
IDAHO	Idaho Falls	Idaho A.A.	8:00, 1st Sat.	475 J St.	Mrs. O. W. Hendrickson, 475 J St.
ILLINOIS	Chicago	†*Chicago A.S.	3:00, 2nd Sun.	Adler Planetarium	J. A. Anderer, 7929 S. Loomis Blvd. (20)
	Galesburg	†*G'burg Am. Ast'mers	7:30, 1st Wed.	Knox Obs.	H. L. Horein, 1246 N. Morton Ave.
	Geneva	*Fox Valley A.S.	8:00, 2nd Tue.	Geneva City Hall	Joseph Zoda, 420 Fellows St., St. Charles
	Lombard	†*Tree Towns A.C.	7:30, Various days	26 S. Westmore	Larry Ewing, 26 S. Westmore
	Moline	†*Popular A.C.	7:30, Wed.	Sky Ridge Obs.	Carl H. Gamble, 3201 Coaltown Rd.
	Peoria	Ast. Sec., Acad. Sci.	8:00, 1st Wed.	Glen Oak Pk. Pav'n.	R. P. Van Zandt, 156 N. Eleanor Pl. (5)
INDIANA	Indianapolis	†*Indiana A.S.	2:15, 1st Sun.	Riley Library	W. E. Wilkins, 6124 Dewey Ave. (19), IR-5946
IOWA	Des Moines	Ia. Div., Gt. Pl. A.S.	2:00, 3rd Sun.	Drake Obs.	Dale Cruikshank, 3655 67th St. (10)
KANSAS	Wichita	†*Wichita A.S.	8:00, 1st Wed.	Friends Univ.	S. S. Whitehead, 425 N. Lorraine (8), 62-6642
KENTUCKY	Louisville	†L'ville A.S.	8:00, 1st Tue.	Univ. of Louisville	B. F. Kubaugh, 207 Sage Rd. (7)
	Louisville	†*L'ville Jr. A.S.	7:30, 3rd Tue.	Private homes	Carol Lipphard, 2421 Calvin Ave. (6)
LOUISIANA	Gretna	Gretna A.S.	7:00, 2nd, 4th Sat.	209 Newton St.	John A. Gunther, 209 Newton St., FO 1-0034
	Lake Charles	†*Lake Charles A.A.C.	7:45, 2nd Tue.	H.S. Chem. Lab.	Norman G. Lore, 532 Alamo St.
	New Orleans	A.S. of N.O.	Irregular	Cunningham Obs.	Dr. J. Adair Lyon, 1210 Broadway
	New Orleans	N.O.A.A.A.	7:30, 2nd, 4th Sat.	DeLaSalle H.S.	Wm. E. Wulf, 2107 Annunciation St. (13)
MASSACHUSETTS	Cambridge	†*Bond A.C.	8:00, 1st Thu.	Harvard Obs.	R. Smith, 519 Quincy Shore Dr., No. Quincy 71
	Cambridge	†*A.T.M.s of Boston	8:00, 2nd Thu.	Harvard Obs.	W. Knight, 75 S. Crescent Cir., Brighton 35
	Springfield	†*S'field Stars	8:00, 2nd Wed.	Private homes	J. Welch, 107 Low'r B'verly Hills, W. S'field
	Worcester	†*Aldrich A.S.	7:30, 1st, 3rd Tue.	Mus. Natural Hist.	W. C. Lovell, 24 Courtland (2), 3-1559
MICHIGAN	Battle Creek	†B. C. A.A.C.	8:00, 2nd Fri.	Kingman Museum	Mrs. W. V. Eichenlaub, 47 Everett Ave.
	Detroit	†*Detroit A.S.	2:30, 2nd Sun.	Wayne U., State Hall	E. R. Phelps, Wayne University
	Jackson	*Jackson A.S.	7:30, 2nd Thu.	Public Library	Allen Bell, 1103 Hamlin Pl.
	Kalamazoo	†Kalamazoo A.A.A.	8:00, Sat.	Private homes	Edgar Pashby, 420 Evelyn Ave.
	Lansing	†*Lansing A.A.	8:00, Sat.	Private homes	R. Elliott, 434 Cowley Ave., E. Lansing
	Pontiac	†*Pon.-N.W. Det. A.A.	7:30, 3rd Thu.	Lincoln Jr. H.S.	G. Carhart, 40 Hadsell Dr., FE 2-9980
MINNESOTA	Minneapolis	*J.A.C. of M'polis	4:15, 2nd, 4th Wed.	Public Library	E. Haskins, 3732 Garfield Ave. S., RE-0201
	Minneapolis	†M'polis A.C.	Irregular	Public Library	Maxine Begin, Sci. Mus., M'polis Pub. Lib.
	St. Paul	†*St. Paul Tel. Club	7:30, 2nd, 4th Wed.	Macalester Coll.	Mrs. R. E. English, 1283 Sargent Ave. (5)
MISSOURI	Fayette	†*Central Mo. A.A.	7:30, 3rd Sat.	Morrison Obs.	R. C. Maag, 816½ S. Mass., Sedalia
	Kansas City	†*A.C. of Kans. City	8:00, 4th Sat.	K.C. Museum	Mrs. Laura Kinsey, 4604 Jefferson (12)
	St. Louis	†*St. Louis A.A.S.	8:00, 3rd Fri.	Inst. of Tech., St. L. U.	Mrs. N. Fallert, 1509 N. Berry Rd., Rock Hill (19)

St. Louis, Mo.: St. Louis Astronomical Society, 8 p.m., Academy of Science. Mar. 16, Stuart L. O'Byrne, "The Meaning of the Russell-Hertzsprung Diagram."

Springfield, N. J.: Amateur Astronomical Society of Union County, 8 p.m., Regional High School. Mar. 23, Rev. Joseph Lynch, S.J., Fordham University, "Earth's Shifting Surface."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. Mar. 3, Dr. Leah Allen, Hood College, "The Earth As Our Spaceship."

MIDDLESEX COUNTY, N. J.

A group of teen-agers has organized the Amateur Astronomical Society of Middlesex County, N. J. Meetings are held on the second Saturday of each month at members' homes.

Presently in use are two small refractors, employed chiefly for observing planets and double stars. Plans are being made for a larger telescope.

Persons in the Middlesex County area interested in joining the society may contact Frank Grabas, Jr., 108 Standiford Ave., Sayreville, N. J.

CORNING, N. Y.

The Corning Astronomy Club is cosponsoring, with the Corning Youth Bureau, a junior astronomy club for school children. Meetings are held biweekly, with members of the senior club acting as instructors.

The first meeting, held in January, attracted 31 children and nine adults. A film, "How Many Stars," was shown, followed by a talk on meteorites.

Other topics to be discussed include the various aspects and possibilities of space travel.

HERE AND THERE WITH AMATEURS *(continued)*

State	City	Organization	Time	Meeting Place	Communicate With
MONTANA	Helena	A.A.C. of Helena	7:00, 3rd Wed.	Private homes	Dr. T. J. Mentrum, 328 N. Benton Ave.
NEVADA	Reno	A.S. of Nev.	8:00, 4th Thu.	Univ. of Nevada	Dr. Vernon Frazier, University of Nevada
NEW HAMPSHIRE	Newmarket	*Gr't Bay Am. Ast'mers	7:30, Alt. Tue.	Public Library	A. R. Brackett, 72 Gov't. St., Kittery, Me.
NEW JERSEY	Caldwell	West Essex A.S.	8:30, 2nd Mon.	Caldwell Mun. Bldg.	Donald C. Smith, 19 Francisco Ave.
	Rutherford	A.S. of Rutherford	8:00, 1st Thu.	YMCA	Mrs. Helen Waite, 11 Bryan Ct.
	Springfield	†*A.A.S. of Union Co.	8:00, 4th Fri.	Regional H. S.	Mrs. W. N. Lurcott, 220 High St., Cranford
	Teaneck	†Bergen Co. A.S.	8:30, 2nd Wed.	Obs., H.S. grounds	C. Milos, 631 Ridgewood Rd., Oradell
NEW MEXICO	Las Cruces	†*A.S. of L.C.	7:30, 1st or 2nd Sat.	Private homes	W. H. Haas, 1203 N. Alameda Blvd.
	Roswell	*Pecos Val. S.&T.C.	7:30, 2nd Fri.	Cham. of Comm.	Dr. R. R. Boice, Rt. 2, Box 163A
NEW YORK	Brooklyn	†Junior A.C.	8:00, 3rd Fri.	B'klyn Public Library	Jr. A. C., Pub. Lib., Grand Army Plaza (38)
	Buffalo	†*Buffalo A.A.	7:30, 1st Wed.	Mus. of Science	W. Semerau, 135 Zimmerman Blvd. (17)
	Corning	Corning A.C.	8:00, 1st, 3rd Mon.	Corning Glass Center	W. R. Redmond, 3 E. 3rd St.
	Gloversville	†A.C. of Fulton Co.	6:30, Wed.	Private homes	Emmanuel Weil, 38 E. Blvd.
	Hicksville	L.I. Obs. Ass'n	8:00, Wed.	369 Staples, F'dale	J. Tosto, 369 Staples, Farmingdale
	New York	*A.A.A.	8:00, 1st Wed.	Amer. Mus. Nat. Hist.	G. V. Plachy, 201 W. 79th (24), EN 2-7100
	Rochester	†Ast. Sec., Acad. Sci.	8:00, 1st Fri.	Rochester Museum	Margaret Frisch, 38 Harris St. (21)
	Schenectady	†*S'tady A.C.	7:30, 3rd Mon.	Union Coll., C.E. Bldg.	C. E. Johnson, 102 State St.
	Syracuse	†*Syracuse A.S.	8:00, 4th Thu.	Syr. U., 206 Steele	Dr. G. J. Mittelman, 110 Gray Ave. (6)
	Troy	†*Renss. Ap. Soc.	8:00, Fri.	R.P.I. Obs.	Dr. Robert Fleischer, R.P.I.
	Troy	†*Troy A.C.	8:00, 4th Sat.	Private homes	P. Cenni, 2316 6th Ave.
	Utica	†*Utica Am. Ast'mers	7:30, 4th Tue.	Proctor Inst.	S. Wolczanski, 506 William St.
	Wantagh	Long Island A.S.	8:00, Sat.	Private homes	A. R. Luechinger, 2009 Seaford Ave., 1571
N. CAROLINA	Chapel Hill	†*Chapel Hill A.C.	8:00, Alt. Wed.	Morehead Plan.	C. C. Tucker, Jr., Morehead Planetarium
	Charlotte	†*Charlotte A.A.C.	8:00, Last Mon.	Myers Pk. H.S.	Mrs. L. W. Kelly, 1014 Kennilworth Ave. (3)
	Greensboro	†*Greensboro A.C.	8:00, Fri.	Woman's Coll., U.N.C.	Dr. A. D. Shaftesbury, 315 Tate St.
	Winston-Salem	†*Forsyth A.S.	7:30, Last Fri.	Private homes	Kenneth Shepherd, 903 W. End Blvd.
NORTH DAKOTA	Grand Forks	†*Red River A.C.	8:00, 2nd, 4th Mon.	City Hall	L. G. Peck, 2101 1st Ave. North
OHIO	Akron	*A.C. of Akron	8:00, Last Fri.	YMCA	Mrs. R. J. Couts, 878 Kennebec Ave. (5)
	Cincinnati	*Cin. A.A.	8:00, Various days	Cincinnati Obs.	James T. Mettey, 2914 Minot Ave. (9)
	Cincinnati	*Cin. A.S.	8:00, 3rd Fri.	Obs., Zion Rd., M. Hts.	Isolina Cartlidge, 5556 Raceview Ave. (11)
	Cleveland	Cleveland A.S.	8:00, Fri.	Warner & Swasey Obs.	Mrs. Helen Strohm, Warner & Swasey Obs.
	Columbus	*Battelle A.C.	Noon, Wed.	Battelle Mem. Inst.	William J. Stahl, Battelle Memorial Institute
	Columbus	†*Columbus A.S.	8:00, 2nd Sat.	McMillin Obs.	Miss R. A. Charlton, 1361 E. 22 Ave. (11)
	Dayton	Miami Valley A.S.	8:00, 2nd Fri.	Nat. Hist. Museum	F. E. Sutter, 5038 Lebanon Pike (9)
	Lorain-Elyria	*Black River A.S.	8:00, 3rd Wed.	YWCA	George Diedrich, 653 Weller Rd.
	Marietta	Marietta A.S.	Irregular	Cisler Terrace	Miss L. E. Cisler, Cisler Terrace
	Newark	Newark A.S.	7:30, 3rd Sat.	YMCA	Gene Cooperrider, 326 N. 11th St.
	Toledo	Toledo Ast. Club	...., 3rd Tue.	Univ. of Toledo Obs.	E. D. Edenburn, 4124 Commonwealth Ave.
	Warren	Mahoning Val. A.S.	8:00, Fri.	Private homes	C. R. Prather, 1363 Drexel, NW, 4494-2
	Youngstown	*Y'town A.C.	7:30, 1st Fri.	Homestead Pk. Pav'n.	F. W. Hartenstein, 907 Brentwood
OKLAHOMA	Tulsa	†*A.C. of Tulsa	7:30, 1st Sat.	Private homes	J. C. Wells, 524 S. 78th E. Ave.
OREGON	Portland	†*Portland A.S.	7:30, 1st Tue.	Central Public Lib.	Mrs. Marge Krutsinger, 6525 NE Davis St. (16)
	Portland	†A.T.M. & Observers	8:00, 2nd Tue.	Private homes	Mrs. Marge Krutsinger, 6525 NE Davis St. (16)
PENNSYLVANIA	Beaver	†*Beaver Co. A.A.A.	8:00, 2nd Tue.	Private homes	Mrs. R. T. LuCaric, Brownsdale Plan, Baden
	Harrisburg	†*A. S. of Harrisburg	8:00, 1st Mon.	State Museum	Edward J. Naylor, 320 Wilhelm Rd.
	Millvale	A.A.A. Shaler T'ship	8:00, 1st Fri.	Cherry City Fire House	Cliff Raible, 200 Rebecca Sq. (9)
	Philadelphia	†A.A. of F.I.	8:00, 3rd Fri.	Franklin Institute	Edwin F. Bailey, LO 4-3600
	Philadelphia	†*Rittenhouse A.S.	8:00, Fri.	Franklin Institute	John W. Streeter, LO 4-3600
	Pittsburgh	†*A.A.A. of P'burgh	8:00, 2nd Fri.	Buhl Planetarium	Mary Burcik, 315 Moore Ave. (10)
	Pottstown	†Pottstown A.A.C.	7:30, Fri.	Public Library	W. E. Schultz, Public Library
	Springdale	*Alleghany Val. A.A.A.	8:00, 1st, 3rd Fri.	Private homes	Wm. E. Stocks, 215 Carson St.
RHODE ISLAND	N. Scituate	Skyscrapers, Inc.	8:00, Mon. or Wed.	Seagrave Mem. Obs.	Seagrave Mem. Obs., Box 157
TENNESSEE	Chattanooga	†*Barnard A.S.	8:00, 3rd Fri.	Jones Observatory	A. H. Jones, 411 W. 21st St., 5-1646
	Memphis	†*Memphis A.S.	7:30, 2nd Sat.	Memphis Museum	Ned Lawrence, 3081 Chisca Ave.
	Nashville	*Barnard A.S.	8:00, 2nd Thu.	Dyer Observatory	Miss C. Kidd, Dyer Obs., Vanderbilt U.
TEXAS	Abilene	*Abilene A.S.	7:30, 4th Mon.	Phys. Rm., H.-S.U.	T. D. Roberts, Hardin-Simmons Univ.
	Austin	†*Forty Acres A.C.	7:30, 1st Tue.	U. of Tex., Physics Bldg.	Forty Acres A.C., Box 7994, Univ. Sta.
	Brownfield	*Brownfield A.C.	8:00, 3rd Wed.	Private homes	Charles W. Isbell, Brownfield 2074
	Dallas	†Texas A.S.	8:00, 4th Mon.	Various auditoriums	E. M. Brewer, 5218 Morningside, UN 3-3894
	Ft. Worth	†*Ft. Worth A.S.	8:00, 4th Thu.	Children's Museum	James M. McMillen, 604 Tierney Rd. (3)
	Houston	Houston A.A.C.	...., 1st Fri.	Nat. Hist. Museum	W. W. Myers, 7424 Tipps St. (23)
	Laredo	*Laredo A.C.	8:00, 2nd Tue.	Laredo Jr. Coll.	Sidney Freidin, Box 1148
	Port Arthur	†*Port Arthur A.C.	7:30, 2nd Thu.	5228 Fifth St.	F. T. Newton, 5213 Fifth St., 2-4807
UTAH	Salt Lake City	*A.S. of Utah	8:00, 2nd Thu.	City and County Bldg.	James W. Geertsen, 4461 S. 9th East St.
VIRGINIA	Harrisonburg	Astral Society	Monthly	Vesper Heights Obs.	M. T. Brackbill, Eastern Mennonite College
	Norfolk	†*Norfolk A.S.	8:00, 2nd Thu.	Museum of Arts	A. Hustead, U.S. Weather Bureau, LO 3-4368
	Richmond	†*Richmond A.S.	8:00, 1st Tue.	601 E. Franklin St.	B. S. Ragland, 601 E. Franklin St. (19)
	Roanoke	*Am. Ast'mers of Roa.	...., 3rd Fri.	Bank of Virginia	Robert Ayers, 828 Stewart Ave. SE, 4-9398
WASHINGTON	Seattle	†*Seattle A.A.S.	8:00, 2nd Wed.	Eagle'n Hall, 1417 E. 42	Norman Dalke, 3640 Densmore Ave.
	Spokane	†*A.T.M.s of Spokane	8:00, Last Fri.	Private homes	Sue Stockton, S. 2129 Grand Blvd.
	Tacoma	†Tacoma A.A.	8:00, 1st Mon.	Coll. of Puget Sd.	Mrs. Roy Atkinson, 2816 N. Union Ave.
	Yakima	†*Yak. Am. Ast'mers	8:00, 2nd Mon.	Cascade Creamery	Edward J. Newman, 324 W. Yakima Ave.
WEST VIRGINIA	Fairmont	†Fairmont A.A.A.	7:30, 2nd Fri.	State Coll., Sci. Hall	David Meisel, 800 8th St.
WISCONSIN	Beloit	†*Beloit A.S.	7:30, 2nd, 4th Wed.	YMCA Bldg.	K. E. Patterson, 318 Public Service Bldg.
	Madison	†Madison A.S.	8:00, 2nd Wed.	Washburn Obs.	Dr. C. M. Huffer, Washburn Obs.
	Milwaukee	†*Milw. A.S.	7:45, 3rd Fri.	Finney Branch Lib.	E. A. Halbach, 2971 S. 52 St. (15)
	Sheboygan	*Sheboygan A.S.	7:30, 2nd Tue.	Mead Public Lib.	Edward Parnitzke, Jr., Route 2

A Brief Text in Astronomy

W. T. Skilling

R. S. Richardson

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BOOKS AND THE SKY

THE HISTORY OF THE TELESCOPE

Henry C. King. Sky Publishing Corporation, Cambridge 38, Mass. (Eastern Hemisphere, Griffin, London), 1955. 456 pages. $12.50.

THIS BOOK represents, the author writes in the preface, "the first attempt to give the history of the telescope the prominence it deserves." In giving it this prominence, Dr. King has written a volume interesting in many ways and deserving of the attention of a wide range of individuals who make or use telescopes or who would like to do so.

The author is senior lecturer in the department of ophthalmic optics, Northampton Polytechnic, London. For many years he has been collecting material for this history; the very large number of references (which will be welcomed by those who wish to follow up details of the subject) shows the diligence with which he pursued his study. The book takes on an added interest when one reads in the author's preface that in 1951 the manuscript was approved by the University of London for the award of the Ph.D. degree. The reviewer hastens to add, however, that the book is not a dull academic account of the type many associate with a doctor's thesis.

In 19 chapters Dr. King traces the history of observational astronomy from use of the Egyptian merkhet to the 200-inch Hale reflector and radio telescopes. The principal story begins in 1608 when Hans Lippershey, a Dutch spectacle maker, constructed a telescope. With Dr. King we put aside the many conflicting accounts of just how Lippershey happened on the lens combination that worked. News of the invention spread rapidly throughout the continent, and in 1609 Galileo turned a telescope of his own manufacture on the stars. The subsequent improvements made on Galileo's simple telescope and the story of the telescope's use in astronomy are traced in detail. The chapters on aerial telescopes, Newton and his work in optics (including the famous incorrect conclusion concerning dispersion that delayed the development of the achromatic lens), Herschel as optician and instrument maker, the story of Hall, Dollond, and the mathematicians who worked on the problem of an achromatic objective, the account of Lord Rosse and his great reflector, remain particularly vivid in the reviewer's memory. They illustrate very well the problems with which the early users of telescopes had to cope.

The reader will also find it interesting to follow the development of some of the more important scientific instrument manufacturers. From Dr. King's account, we quickly realize the important role in astronomy played by the early craftsmen who designed and built the equipment used by the astronomers. One also realizes with some sadness what a small percentage of the fine instruments constructed at such great pains produced important astronomical results; the point is emphasized on several occasions.

To me the latter part of the book, dealing generally with the past three quarters of a century and in particular with the past 50 years, did not appear to be as clearly developed as that covering the earlier history of the subject. The thread of the later story is very broken because of the way in which accounts of the development of the telescope, makers of telescopes, and histories of observatories are intermingled. A different method of presentation, in which each of these subjects would be treated in one chapter or a series of chapters, might have been more conducive to clarity. Perhaps the author has attempted to include too many subjects in a history of the telescope. When he deals with the work of observatories, distortion is likely to occur. Thus, writing about Mount Wilson Observatory, he devotes more space to discussion of a single observing run on Mars and Saturn made by Barnard with the 60-inch reflector than he does to the observatory's total output of work in the spectroscopic and nebular fields.

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Numerous small factual errors are found in the later sections of the book. On page 308 the author mentions James Lick and his wife, but Mr. Lick never married. Again on that page he remarks, in connection with the Lick telescope, "at first a large reflector was contemplated and G. Calver nearly obtained the order." Nothing in the Lick history, particularly the account by Prof. George Davidson, indicates that thinking about a reflector proceeded this far. On page 311, after the construction of the Lick Observatory an endowment of $90,000 remained, not $125,000. Again on page 311, Dr. King confuses the Lick 36-inch refractor with the Crossley reflector, which was used to photograph the planets in many wave-length regions from infrared to ultraviolet. Faults of this type are numerous.

The large number of excellent pictures and diagrams and the numerous references make Dr. King's *History* an outstanding book. Its format and make-up are very pleasing to the eye. In spite of the small factual errors and the distortions that do occur (and it is expected that these will be corrected in a second edition), this book should be in the libraries of all those who have an interest in the telescope and its uses.

HAROLD WEAVER
Leuschner Observatory

FRONTIERS OF ASTRONOMY
Fred Hoyle. Harper and Bros., New York, 1955. 360 pages. $5.00.

A YOUNG Cambridge professor, Fred Hoyle, trained in the sciences and endowed with powerful imagination, expresses startling conclusions in his written books. His latest work, *Frontiers of Astronomy*, will stir up more thinking and controversy than did his previous book, *The Nature of the Universe*.

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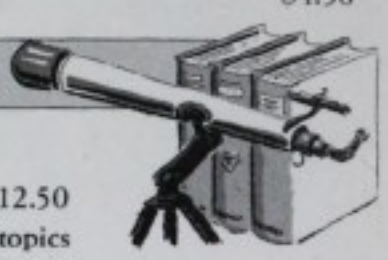

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scientist alike, Hoyle invariably sets up sufficient foundation in each incident that the reader is able to digest the conclusion. He particularly does a brilliant job of explaining the intricacies of nuclear reactions in elementary terms. The complicated steps of stellar evolution are made exceedingly clear.

The easy style of the book makes it hard for the reader to know which statements are agreed to by all astronomers and which ones are the personal views of the author. Sometimes there is no warning, when one of his theories is presented, that it has already been studied and rejected by other experts. Thus the reader is at times in the uneasy position of not being sure what to take on trust.

Hoyle's mission is to sell his steady-state theory to the world. He supplies a wealth of material to support it, but he is bound to run into conflict with others as well trained as himself. He has a tendency to depend too much on still superficial astronomical observations of the cosmos. The best astronomers are not yet sure they have seen a typical sample of the universe. Fundamental to the steady-state theory is the concept of an expanding universe, evidence for which is based upon a delicate shift in the spectral lines of remote galaxies. All astronomers are not satisfied the present interpretation is conclusive, yet Hoyle hangs his hat on the hook with complete assurance.

Although the author has tried to confine his theory to what he terms material things which begin with the simplest element, hydrogen, out of which he asserts all other elements are manufactured in the stellar laboratories, he uses radiation, nuclear cohesion, gravity, and magnetism to bring the evolution about. He admits of no starting point—in fact, he denies one—and would have us believe that all is a continual cycle with new hydrogen being created eternally. He says we must not question the "why" of it. It just is so.

Nevertheless, Hoyle does not believe in accidents, but strongly in the philosophy of cause and effect. There is a cause for everything observed, if we can but find it. How does he know when he has found it? By the way his answer fits into the general scheme of things and appears to make sense.

Frontiers of Astronomy will make its readers think, often as they never have before. Mr. Hoyle renders a great service by exposing cosmic problems. His popularization of astronomy means much to its future progress. The greatest advances in our science are being made with tools obtained through the generosity of laymen and organizations outside the field. Perhaps their interest in astronomy has been stimulated by the writings of men like Hoyle.

VICTOR W. KILLICK
Sacramento Valley Astronomical Society

NEW BOOKS RECEIVED

MARIA MITCHELL, GIRL ASTRONOMER, *Grace Hathaway Melin*, 1954, *Bobbs-Merrill*. 192 pages. $1.75.

Written for children, this is an account of the childhood of a girl on the island of Nantucket a century ago, who observed with her amateur-astronomer father, and who later became an outstanding astronomer herself.

THE POLAR AURORA, *Carl Störmer*, 1955, *Oxford University Press*. 403 pages. $8.80.

An outstanding authority gives a comprehensive account of the aurora primarily for the specialist, describing methods of observation and their results, and mathematical theories of the origin of the aurora.

EXPERIMENTS IN THE PRINCIPLES OF SPACE TRAVEL, *Franklyn M. Branley*, 1955, *Crowell*. 119 pages. $2.00.

The scientific principles underlying rockets are explained for young readers, with the aid of home experiments with coffee cans, rubber tubing, and the like.

SUNSPOT AND GEOMAGNETIC-STORM DATA DERIVED FROM GREENWICH OBSERVATIONS 1874-1954, *Royal Greenwich Observatory*, 1955, *H. M. Stationery Office*, London. 106 pages. £1 5s.

At Greenwich Observatory photographic observations of the areas and positions of sunspots were begun in 1874, and their results are summarized in this volume. It lists annual and monthly means of spot areas and other characteristics, detailed descriptions of the 761 largest spot groups, and there are catalogues of magnetic storms.

STUDIES OF LONG PERIOD VARIABLES, *Leon Campbell*, 1955, *American Association of Variable Star Observers*, 4 Brattle St., Cambridge 38, Mass. 247 pages. $6.00 cloth, $5.00 paper.

At his death in 1951, Leon Campbell was engaged in analyzing the observations of

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brightness of long-period variable stars made by members of the AAVSO up to 1949, and this work has now been prepared for publication by Mrs. M. W. Mayall, present recorder of the society.

Part I lists dates of maxima and minima observed for 390 long-period stars from 1921 to 1949, forming an extension of the earlier list in Harvard *Annals 79*, part 2. The remainder contains tabular and graphical mean light curves for 388 stars, based on more than 570,000 individual observations.

THE COMMON SENSE OF THE EXACT SCIENCES. *William Kingdon Clifford,* 1955, *Dover.* 315 pages. $3.00 cloth, $1.60 paper.

Originally published in 1885, this work is a luminous explanation for laymen of what mathematics is about. J. R. Newman's introduction contains an extended biographical account of the author. This is a reprint of the 1946 Knopf edition.

A MARINER'S METEOROLOGY, *C. G. Halpine* and *H. H. Taylor,* 1956, *D. Van Nostrand.* 371 pages. $8.00.

Written from a mariner's point of view, and a companion to *A Pilot's Meteorology,* the book presents the fundamentals of modern meteorology in clear and simple terms, with many illustrations. This text is used to teach meteorology to students at the U. S. Naval Academy.

AMATEUR ASTRONOMERS' MANUAL, *Laban Lacy Rice,* 1955, *Cumberland University Press,* Lebanon, Tenn. 58 pages. 65 cents, paper bound.

This pamphlet of astronomical data is designed to assist the amateur who has no standard reference books, nor easy access to library facilities. Only the most necessary information on the sun, moon, planets, and stars is included.

IONIZED GASES, *A. von Engel.* 1955, *Oxford University Press.* 281 pages. $6.75.

Writing for advanced students, Dr. von Engel explains the production, motions, and recombination of charged particles in gases—topics of basic importance in astrophysics.

PHILOSOPHICAL WRITINGS OF PEIRCE, *Justus Buchler,* editor, 1955, *Dover.* 386 pages. $4.50 cloth, $1.95 paper.

Selections, in large part dealing with the philosophical basis of scientific method, are given from the works of Charles S. Peirce. This is a reprint of *The Philosophy of Peirce: Selected Writings* (1940).

THE THEORY OF HYDRODYNAMIC STABILITY, *C. C. Lin,* 1955, *Cambridge University Press.* 155 pages. $4.25.

This is a summary, written for specialists, of recent advances in the theory of fluid flow, many of which are applicable in astronomy and geophysics. The volume is one of the *Cambridge Monographs on Mechanics and Applied Mathematics.*

MAN AND THE WINDS, *E. Aubert de la Rue,* 1955, *Philosophical Library.* 206 pages. $6.00.

A popular account of the winds in all parts of the world tells particularly of their effect on mankind. This is a translation by Madge E. Thompson of a French work, *L'Homme et le Vent.*

TEMPERATURE: ITS MEASUREMENT AND CONTROL IN SCIENCE AND INDUSTRY, VOLUME II, *Hugh C. Wolfe,* editor, 1955, *Reinhold.* 467 pages. $12.00.

The 24 chapters are papers read at the third symposium on temperature, held at Washington in October, 1954. Many of the contributions are of significance to the astronomer, notably on astrophysical temperatures, by Cecilia Payne-Gaposchkin; ionization measurements at high temperatures, by W. Lochte-Holtgreven; and temperatures in the upper atmosphere, by H. E. Newell, Jr.

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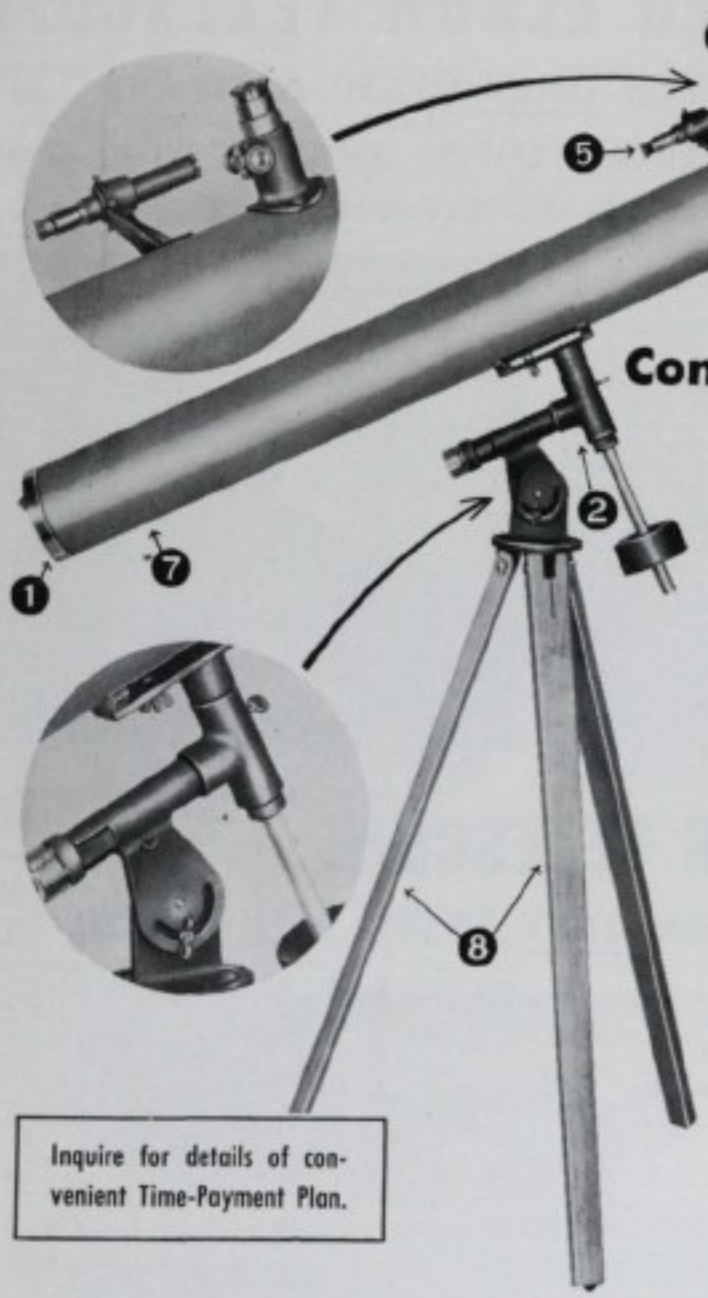

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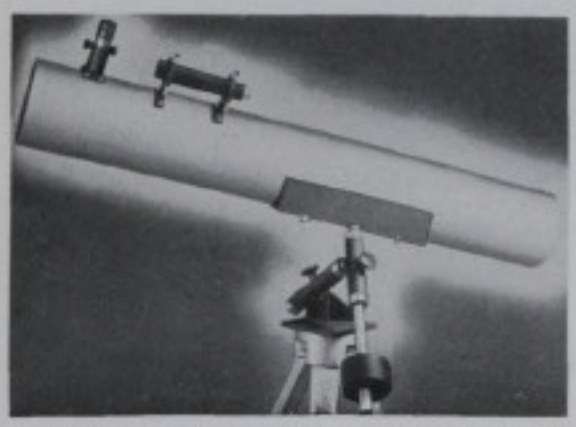

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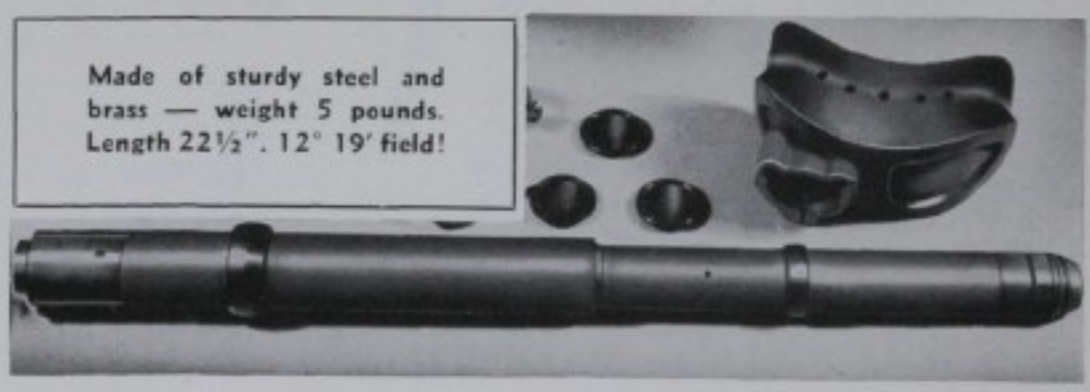

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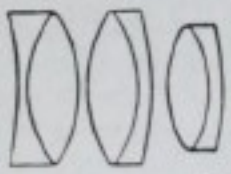

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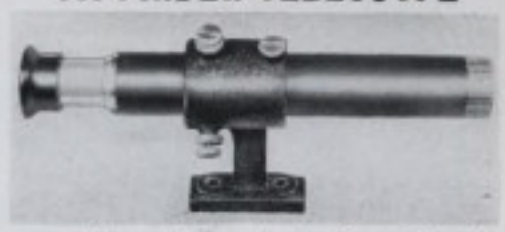

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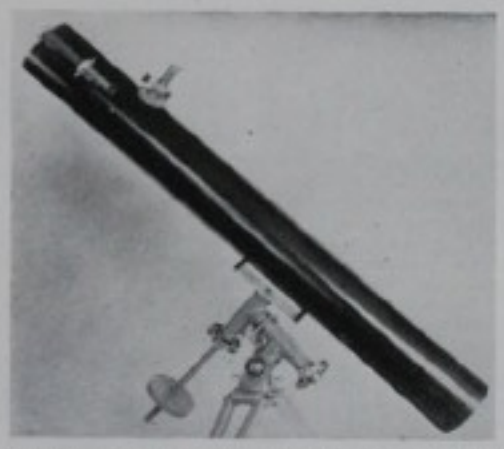

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Notes on Basic Optics—XVIII

R. Procedures in Optical Design

A great deal could be written about optical design—even of the relatively simple achromatic objective. But detailed procedures for the correction of optical systems would mean little except to one studying to become an optical designer. A short discussion of the general philosophy of present-day optical design should interest the amateur, however, and may help to dispel some of the mystery that too often shrouds the optical designer and his activities. His work is certainly complex and difficult, and requires much mathematical skill and insight, but there is nothing mysterious about it.

1. **Orders of Aberrations.** What the designer is trying to do can be clarified by a bird's-eye look at the aberrations of optical systems. It is theoretically possible to write an equation for the path of any ray whatsoever passing through a given optical system. Such an equation will specify how the ray emerges from the system—in terms of its intersection length, convergence angle, or some other measure. The equation will also tell how this measure depends on the parameters of the optical system (such as surface curvatures, refractive indexes and spacings), and on where the ray enters the system (which might be specified by field angle and height in the aperture, for example).

Since the equation is for a general ray, the parameters of the optical system will appear as constants in the equation, and the data for the incident ray will appear as variables. In principle, the equation can be written as an infinite series, in which the variable terms are all of odd order.

For example, such an equation might look like this:

$$\begin{aligned} \mathbf{X} = a_0 &+ a_1\mathbf{h} + a_2\mathbf{\theta} + a_3\mathbf{h}^3 + a_4\mathbf{h}^2\mathbf{\theta} \\ &+ a_5\mathbf{h}\mathbf{\theta}^2 + a_6\mathbf{\theta}^3 + a_7\mathbf{h}^5 + a_8\mathbf{h}^4\mathbf{\theta} \\ &+ a_9\mathbf{h}^3\mathbf{\theta}^2 + a_{10}\mathbf{h}^2\mathbf{\theta}^3 + a_{11}\mathbf{h}\mathbf{\theta}^4 \\ &+ a_{12}\mathbf{\theta}^5 + \quad \cdots \qquad (36) \end{aligned}$$

Here **X** is some property of the emergent ray, and **h** and **θ** are the data of the incident ray, say height in the aperture and field angle. The a's are constants.

For even the simplest optical system, such an equation is so complex that it is nearly impossible to write explicitly, but the theoretical existence of the equation can be proven.

The first three terms on the right side of Equation 36 establish the first-order properties of the optical system. These are the Gaussian properties, derived from the paraxial and thin-lens assumptions.

The next four terms represent the **third-order aberrations**—spherical aberration, distortion, coma, and astigmatism. The next six terms involve the **fifth-order aberrations**, of which only a few have received distinctive names. (Actually, there are more than six aberrations of the fifth order, because the a's in general are compound constants.)

Derivation of the first-order terms of this general equation is quite simple—in effect we have done it when we found the equations for focal length and image height. It is also not too difficult to write down analytical expressions for the third-order terms, for spherical aberration and the like. Such expressions have not been derived in these articles, but they are in general use.

A number of investigators have developed mathematical methods for calculating the fifth-order aberrations. As might be expected, these procedures are complex and laborious, and not generally very useful in practical design.

Chromatic aberration is represented by the difference between Equation 36 as written twice for light of two different wave lengths; thus it cannot be classed as an aberration of any one order. Primary chromatic aberration—dealt with in our July, 1955, installment—is the difference between the first-order terms of ex-

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pressions for the intersection lengths in two different colors. There are, of course, chromatic variations of all the monochromatic aberrations.

2. **Design Procedure.** Almost without exception, the general method of the optical designer is to start with a first-order solution. This consists of determining in a general way the major lens components required (such as objective, erectors, and eyepiece); then choosing appropriate focal lengths and apertures to arrive at a system with the required magnification, speed, pupil diameter, illumination, and the like. We did essentially this in our July, 1954, installment, where we synthesized an optical system. This first-order design is quite simple, and I hope that readers who have followed these articles with some care will try their hand at it.

These preliminary choices are necessarily rather loose, and subject to modification as the detailed design progresses, for some compromises may be needed to achieve adequate optical performance.

Once the first-order design has been obtained, the aberrations are dealt with as follows:

1. Calculate the third-order aberrations by some standard mathematical method and, by making small changes in parameters such as curvatures and spacings, bring the third-order values close to zero for all aberrations important in the system.

2. Next, make an exact ray trace through the system for several selected rays. This determines the sum of the aberrations of all orders, in other words, the real performance of the system. Since third-order terms add to practically zero, the aberrations which result from the exact calculations represent the still uncorrected higher-order aberrations.

3. The designer now returns to the third-order procedures, and deliberately introduces small amounts of third-order aberrations sufficient to balance the higher-order residuals that were determined from the exact ray traces.

4. Steps 2 and 3 are now repeated as often as necessary to bring the optical system within the required tolerances. If the original design choice is fortunate, then the process is convergent, and the final results are attained after perhaps four or five repetitions. But if the system does not respond—as is frequently the case—the designer must boldly change the original elements, perhaps splitting one component into two, or changing glass types, and start over.

This optical-design procedure is much easier and more effective than making small arbitrary changes in the system and tracing rays through it for each step. The calculations for third-order aberrations are much simpler than for exact ray tracing. More important, this procedure tells how each surface contributes to the final aberrations, so the designer knows just where to make changes. Exact ray tracing gives no such surface-by-surface information, and the changes then have to be pure guesswork.

Currently, most optical design groups use electronic digital computers for the exact ray-trace calculations. These computers can calculate at phenomenal speeds, performing in minutes what would require days for a trained operator at a desk calculating machine. But it is hardly worthwhile to program the simple third-order calculations on a computer.

It would be helpful if we could deal with the fifth-order aberrations in the same way as the third-order ones. This is the justification for the development of fifth-order theory. Unfortunately, the calculations are not yet simple enough to be generally useful; however, some work has been done on programming them for electronic computers.

Theoretically, at least, a large electronic digital computer could do the entire job of optical design, including calculation of the third-order aberrations, adjusting the parameters, and final convergence. Some progress has been made toward this. Dr. James G. Baker, working with the Harvard Mark IV computer, has developed methods by which the machine, fed with data for three types of glass and a required aperture and focal length, as well as criteria for judging the quality of a solution, will compute the best possible triplet lens.

(To be continued)

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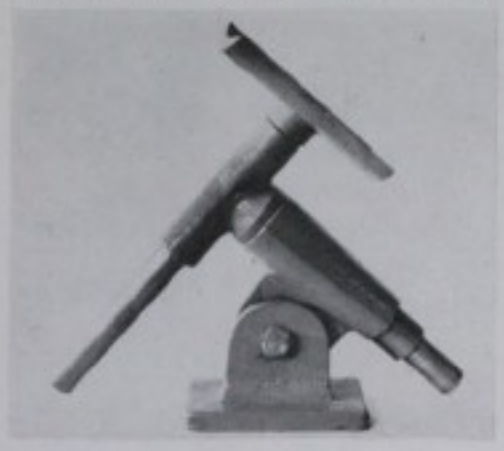

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Twin 12½-inch Short-focus Newtonian Reflectors

PICTURED on the front cover of this issue are twin telescopes that have many distinctive advantages for amateur observers. They are identical short-focus portable 12½-inch reflectors that can be taken apart and packed in a car for transport to observing sites. Only the tube of each instrument is so large as to require transportation on the roof of an automobile.

The mountings were designed and built by Clarke Harris, of Torrance, Calif., who is seen in the photograph on the facing page. He has taken one of the telescopes apart, using only the crescent wrench that is lying on the grass next to the mirror and cell.

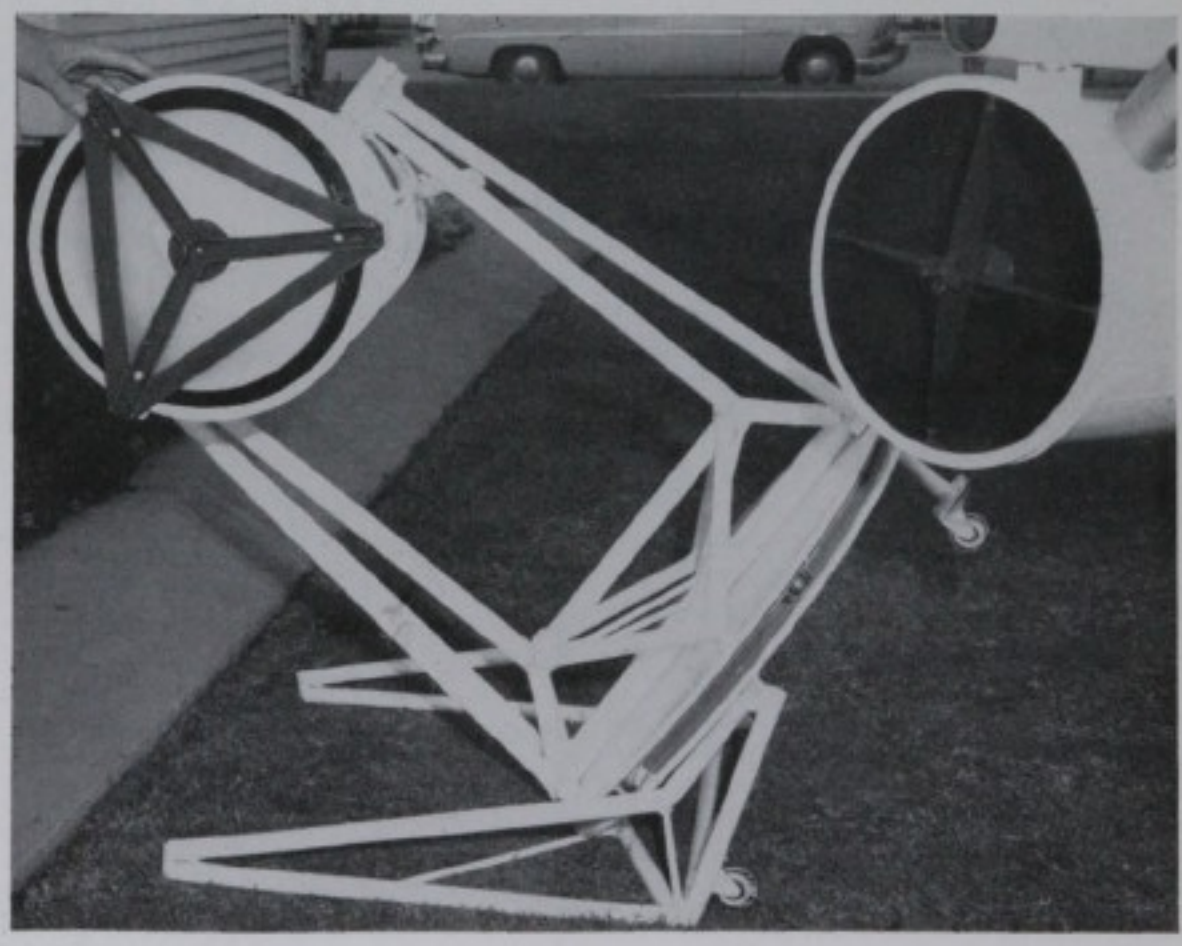
When assembled, each telescope rests on the casters bolted to the bottom plate, and in this position may be rolled from place to place. It is a simple matter to lower to the ground the "handles" that are used during such rolling, whereupon the telescope becomes an equatorial ready for the night's observing. A pair of 28" diameter ⅜" boiler-plate disks, separated by six 1" steel balls, provides for movement in right ascension (or in azimuth when the plates rest horizontally). A ⅞" aircraft bolt, 2¾" long, rotating in a Timken thrust II 1755/1729B bearing, holds the two plates together.

The design is such that when the mounting is put in the equatorial position at least two of the balls are lower than the bolt, and a physical couple is set up between the lower balls and the bolt. If four or fewer balls were used, severe rocking would result; five should work, but six are much better.

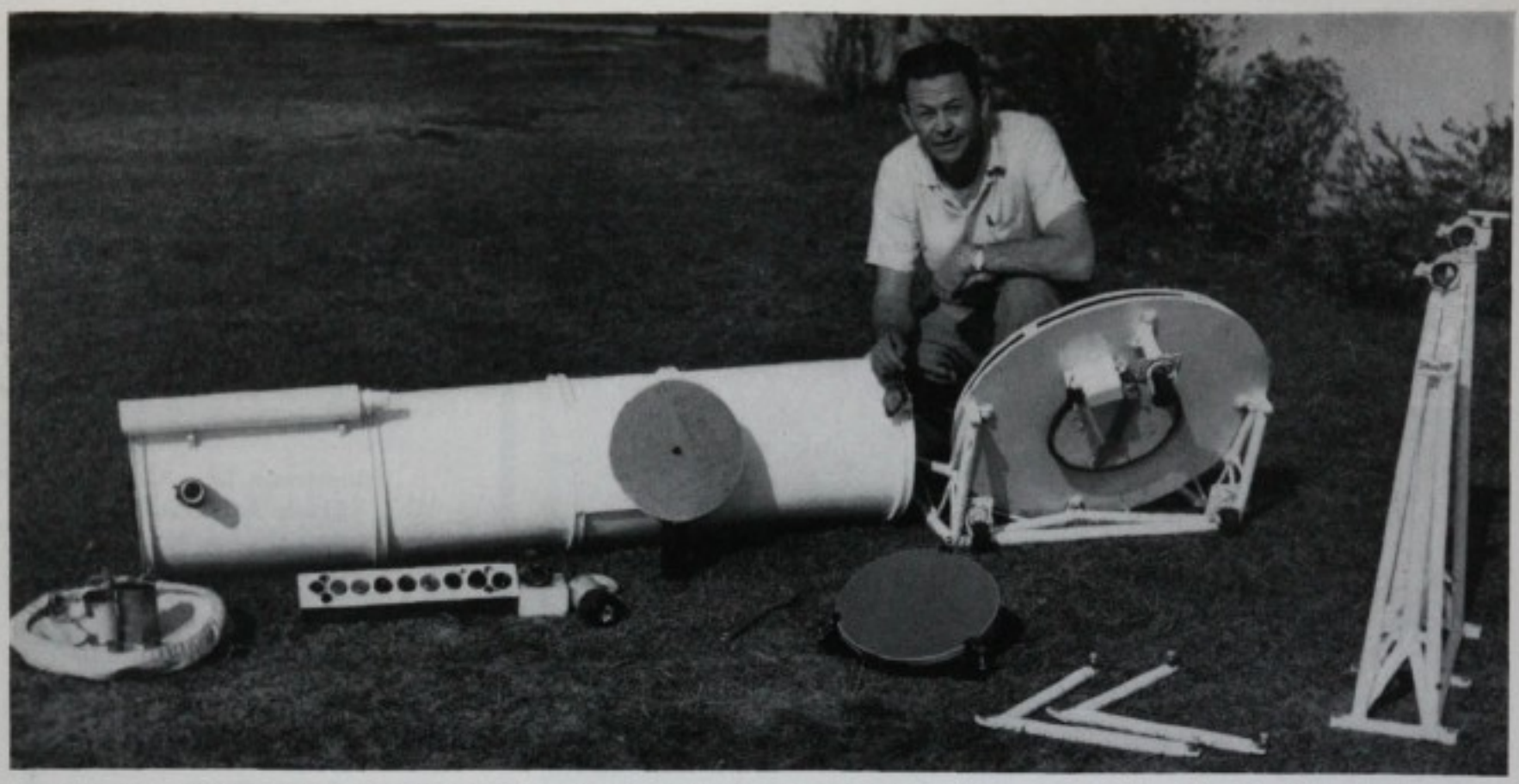
Just below the upper boiler-plate disk is a thin sheet of aluminum with six "cages" attached for defining the positions of the balls, as can be seen in the photograph. Little or no smoothing of the ball races is needed because of the large size of the balls. Of course, any obvious bumps were removed with emery cloth. Several small children playing merry-go-round served to seat the balls well on these particular instruments!

The base portion is normally a single unit when the instrument is taken apart for transport; it is the heaviest part, weighing some 150 pounds. The angle of its two main fork arms depends on the latitude. These arms are made of ¾" pipe with ¼" tubing used for stiffening. The extra stiffeners seen in the first model (to the right on the front cover) proved unnecessary, so they were omitted on the second. On the ends of the forks serving as legs are lugs with screws to provide for small adjustments of the polar axis in altitude. The arms of the base fork were bolted to the bottom plate to avoid warping that might be caused during welding. One of the casters is bolted to the bottom plate rather than welded, for the same reason.

Mounted on the upper plate is a modified series of welded "A" frames that make up a rigid fork to hold the telescope tube. All the parts attached to the base plate are bolted rather than welded—these bolts permit quick disassembly. The length of the fork arms depends upon the focal length of the telescope and the position along the tube at which the declination axis is set. The fork arms are long enough



The mirror support of one telescope (left) and the diagonal spider support of the other are seen here. Photograph by Harold Turner.



The 12½-inch reflector is easily taken apart for transport in a car. The base plate remains one unit with the clutch, gear, hour circle, and pointer. Mr. Harris is holding a spare drive motor in his hand. Photograph by Harold Turner.

to permit the tube to be turned between them for observing in the vicinity of the north celestial pole.

Sleeve bearings with split housings on the ends of the forks hold the telescope tube and form the declination axle (or altitude motion), and can be tightened for proper friction adjustment.

The telescope tube is 67″ long, 14″ inside diameter, with a wall thickness of 0.051″. It weighs about 35 pounds, including stiffening rings, spider assembly, eyepiece adapter, and trunnion shafts. The tube is inside-riveted its full length, which was accomplished with Mr. Harris outside and his son inside during the riveting process.

For the secondary support, the four spider vanes attach directly to a piece of 2″ bar stock milled into four offset sections, as can be seen in the picture showing the upper end of one tube. A hole slightly larger than ⅜″ is counterbored on the bar's axis. A ⅜″ drill rod slips through the hole, and is centered with four small Allen screws running in almost parallel to the spider vanes. Threaded to the drill rod is a flat disk whose diameter is that of the brass tubing used to hold the diagonal mirror. A piece of milled steel dowel cut on a 45° angle was slipped inside the brass tubing as a plug, then the 45° side of the brass tube was pinned over ⅛″ to hold the diagonal mirror. Mr. Harris prefers the use of stainless steel wool as backing for the secondary. The inside of the brass tube is threaded and screwed onto the threaded metal disk on the drill rod. (I have suggested that a small wing nut or similar safety device be put on the upper end of the drill rod as a precaution against the diagonal's slipping out some time and causing considerable trouble.)

The primary mirror cell is made chiefly of 1″-by-½″-by-⅛″ steel channel. The three screw heads seen emerging from the channels are not for collimating, which is accomplished by position nuts on the three bolts that hold the cell to the telescope. Notice in particular the adequate ventilation for the primary, a very important item in a telescope with a full tube. The mirror clearance is ¾″.

Stability is always the big problem with portable mountings. Mr. Harris states that complete settling after a severe jolt requires four seconds in the altazimuth arrangement, and seven seconds in the equatorial.

To perform well, short-focus telescopes require mirrors and secondaries of excellent figure—the requirements are much more critical than for instruments of longer focal ratio. These two telescopes are f/5.68, with secondaries of 2.142″ minor axis. These optics were made by Thomas R. Cave, Jr., Long Beach, Calif., with surfaces accurate to 1/10 wave, and the telescopes perform as well as any others of their aperture.

Using one of the instruments, Mr. Cave found two divisions in the ring of Saturn not previously reported to the Association of Lunar and Planetary Observers, one of which I later confirmed with my 12-inch f/7. Most of Mr. Cave's Mars drawings for the 1954 apparition were made at this telescope, and they are among the best drawings sent to the ALPO Mars recorder.

For variable star work, these large reflectors are most efficient, as they can observe 15th-magnitude stars consistently. To reach the eyepiece when the telescope is pointed high in the sky requires not much more than a small kitchen ladder. Fields of galaxies, such as the Virgo clus-

Read This Advertisement

Here is a combination of a Barlow and a particular ocular which gives outstanding results. It consists of our new Barlow and our 16.8-mm. (⅔″ focal length) Erfle eyepiece. While the Barlow was not specifically designed to work with this eyepiece, it does so to an astonishing degree. All images are sharp and hard to the very edge of the field.

The Barlow gives magnification up to slightly over three times that of the ocular alone. It is achromatic, coated, and mounted to the U. S. standard size of 1.250 inches.

The Erfle ocular has a field of approximately 68 degrees with excellent eye relief. The combination gives the equivalent focal length of slightly under 6 mm. Many users state it is far superior to any shorter focal length ocular of equivalent magnification.

The Barlow sells for $16.00 postpaid, and the Erfle for $14.75 postpaid. Both are guaranteed to perform as above stated or money refunded.

ORTHOSCOPIC OCULARS—All hard coated, standard 1¼-inch outside diameter.

28-mm.	$15.00	10.5-mm.	$16.25	4-mm.	$17.25
16.8-mm. (Erfle)	$14.75	7-mm.	$17.25	Barlow 3x	$16.00

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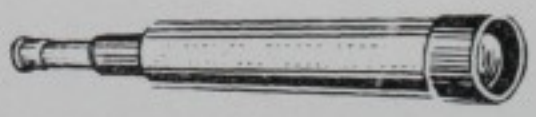
"GIANT" 3-inch TELESCOPE



40 power

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Never before has anything like this been offered at so low a price. Here is another example of American ingenuity. Big 3" diameter achromatic coated objective which will give needle-sharp crystal-clear images. Focusing is a delight with the micrometer spiral focusing drawtube. Light-weight aluminum construction throughout, black crackle finish, length open 22 inches, closed 17 inches. This telescope gives an upright image—it is WONDERFUL for astronomy, SUPERB for long distances, EXCELLENT as a spotting scope.

A PERFECT GUIDE TELESCOPE..... Special Price **$57.50**

Aluminum Telescope Tubing

O.D.	I.D.	Price Per Ft.
2⅛"	2⅛"	$1.20
3⅛"	3¼"	1.75
4½"	4⅛"	2.75
5"	4⅞"	2.75

All tubing is shipped POSTPAID

Focusing Eyepiece Mounts Rack & Pinion Type

The aluminum body casting is finished in black crackle paint and is machined to fit all our aluminum tubing. Has a chrome-plated brass focusing tube, which accommodates standard 1¼" eyepieces.

For 2⅛" I.D. Tubing	Postpaid	$12.95
For 3¼" I.D. Tubing	"	12.95
For 4⅛" I.D. Tubing	"	12.95

Reflector type for all size tubing.
Complete with diagonal holder..... $ 9.95

Aluminum Lens Cells Black Anodized

Cell for Lenses	Cell Fits Tubing	Price
54 mm Diam.	2⅛" O.D.	$ 3.50
78 mm "	3⅛" "	6.50
81 mm "	3⅛" "	6.50
83 mm "	3⅛" "	6.50
110 mm "	4½" "	10.50

MOUNTED EYEPIECES

The buy of a lifetime at a terrific savings to you. Perfect war - surplus lenses mounted in black anodized standard aluminum 1¼" mounts.

F.L.	TYPE	PRICE
12.5 mm (½")	Symmetrical.....	$ 6.00
16 mm (⅝")	Erfle (wide angle)...	12.50
16 mm (⅝")	Triplet.....	12.50
18 mm (¾")	Symmetrical.....	6.00
22 mm (²⅞₂")	Kellner.....	6.00
32 mm (1¼")	Orthoscopic.....	12.50
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The above eyepieces can be supplied COATED at 75 cents each extra.

AN ECONOMICAL EYEPIECE

This mounted eyepiece has two perfect fluoride-coated lenses 29 mm in diameter. It is designed to give good eye relief. It has an effective focal length of 1¼" (8x). The eyepiece cell fits a 1¼" tube.... $4.50

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$125.00 Value..... **$18.50**

BRAND NEW COATED 1¼" E.F.L. wide-angle eyepiece. Contains 3 perfect achromats.

Aperture is 1 3/16". (Illustrated) **$12.50**

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2. Air-spaced
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4. Precision Mounted — Ready to Use
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6. 3¼" or 4⅛" CLEAR APERTURE f/15
7. 48" or 62" FOCAL LENGTH
8. Quality Can't Be Beat
9. Lowest Price
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Each lens is thoroughly tested by us and is guaranteed to resolve two seconds of arc or better. They are corrected for the C and F lines (secondary chromatic aberration). The zonal spherical aberration and the chromatic variation of spherical aberration are negligible. The cell is machined to close tolerances so that it will fit directly over our standard aluminum tubing, eliminating any mounting problems.

3¼" diam., 48" f.l. (uncoated). **$28.00** — Same as above with coating.... **$32.00**

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Diameter	Focal Length	Each	Diameter	Focal Length	Each
54 mm (2⅛")	254 mm (10")....	$12.50	83 mm (3¼")	660 mm (26")....	$28.00
54 mm (2⅛")	300 mm (11.8")....	12.50	83 mm (3¼")	711 mm (28")....	28.00
54 mm (2⅛")	330 mm (13")....	12.50	83 mm (3¼")	762 mm (30")....	28.00
54 mm (2⅛")	390 mm (15.4")....	9.75	83 mm (3¼")	876 mm (34½")....	28.00
54 mm (2⅛")	508 mm (20")....	12.50	83 mm (3¼")	1016 mm (40")....	30.00
54 mm (2⅛")	600 mm (23½")....	12.50	102 mm (4")	876 mm (34½")....	60.00
54 mm (2⅛")	762 mm (30")....	12.50	108 mm (4¼")	914 mm (36")....	60.00
54 mm (2⅛")	1016 mm (40")....	12.50	110 mm (4⅜")*	1069 mm (42 1/16")	60.00
78 mm (3 1/16")	381 mm (15")....	21.00	110 mm (4⅜")	1069 mm (42 1/16")	67.00
80 mm (3⅛")	495 mm (19½")....	28.00	128 mm (5¹⁄₁₆")*	628 mm (24¾")....	75.00
81 mm (3 3/16")	622 mm (24½")....	22.50	128 mm (5¹⁄₁₆")	628 mm (24¾")....	85.00

*Not coated

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A. JAEGERS — 6915 Merrick Road, LYNBROOK, N. Y.

ter, are marvelous in a dark sky, and the planets and moon are equally well viewed. Mr. Harris observes the sun by adding a Herschel wedge and a No. 10 welder's shield. Thus, these reflectors are very versatile.

THOMAS A. CRAGG, JR.
246 W. Beach Ave.
Inglewood 3, Calif.

MIRROR PERFORMANCE

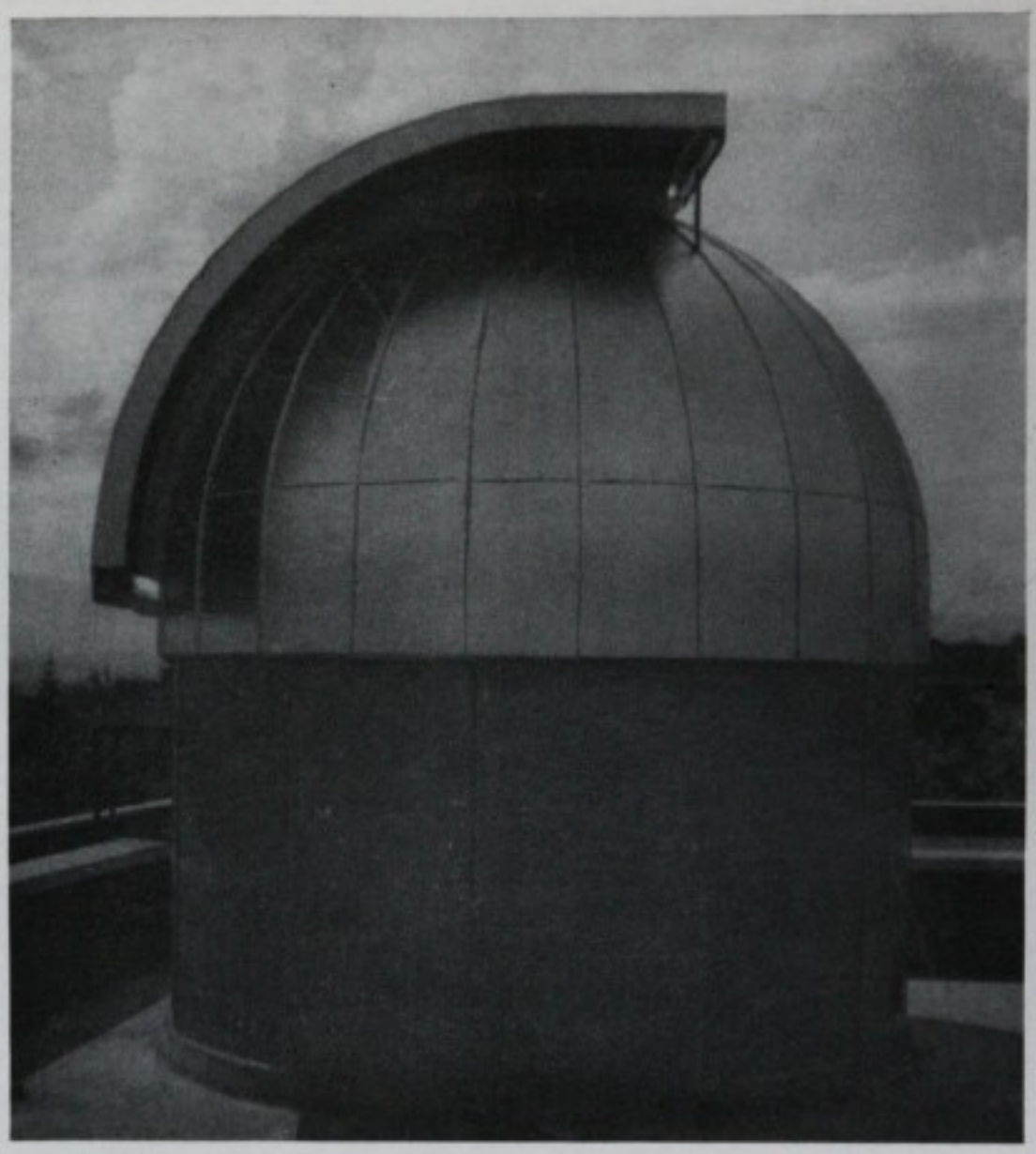
IN A REPORT in the *Bulletin* of the Astronomical League, November-December, 1955, the chairman of the instruments section, Thomas R. Cave, Jr., writes:

"Since it is impossible ever to measure at the radius of curvature the exact center or exact edge of a mirror, it is always better to feel that the mirror is undercorrected before actually using it on the stars. Chances are that, if left 10 or 15 percent undercorrected by knife edge test, on the stars the mirror will appear almost exactly perfect. Many amateurs worry unnecessarily over a very minute error at or near the center of the mirror, paying much less attention to near the edge areas. Actually a small error in the center, even when not masked by the secondary mirror, is of little importance, while errors far more minute at the edge portions of the mirror will cause more trouble in definition under actual star performance.

"The final proof of the excellence of the telescope is in its actual performance with high magnifications on the stars and planets when the air is steady and 'seeing' is near perfect. It is best to select a star of about third or fourth magnitude. In the summer *Epsilon Lyrae* is excellent as a quadruple star, but any good double or single star that is not too bright will do. Use roughly 300x on a six-inch, 400x on an eight-inch, and 500x on a ten-inch, and carefully examine the star image slightly outside focus and by the same amount inside focus. The shadow of the diagonal flat should appear the same size, or nearly so, at the same distance each side of the focus, and the interference diffraction rings should appear the same if the mirror, diagonal and oculars are perfect, or very nearly so. Mirrors which give absolutely identical images each side of focus and equal diameter shadows of the diagonal are a real treasure and comparatively rare."

CELESTIAL GLOBE FOR SALE

Colgate University has for sale a 36-inch-diameter celestial globe, made by Malby and Co., London, in 1845. This historic globe, which is well preserved, is mounted in a full meridian ring; and it shows stars and double stars with their magnitudes, as well as nebulae and the zodiacal constellation figures. Inquiries should be addressed to Prof. Theodore Herman, Department of Geography, Colgate University, Hamilton, N. Y.



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Here, for example, at the Central Washington College of Education, Ellensburg, Wash., the completed observatory harmonizes with existing color schemes. The illustrated dome has an aluminum exterior with a gray substructure. The interior is painted two-tone blue, giving a pleasing color combination and highlighting the college's 8-inch reflector.

Practical, as well, is the oversized steel entrance door which allows large and bulky equipment to be moved in and out with little difficulty. Located on top of the science building, the observatory structure is made entirely of steel (pictured on page 174 last month), weighs 8,000 pounds, and is vibration-free.

When first planning an observatory, the college thought it would be a costly and long-in-coming project. An inquiry to ASTRO-DOME proved that not only was an observatory possible within a reasonable period of time but the college was also able to finance a *complete* installation within its limited budget.

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WHAT TO EXPECT OF A SMALL TELESCOPE

It has long been known that small telescopes like Questar enjoy unique advantages over larger instruments. Size for size, nature has so arranged matters that the little fellows are relatively much more efficient. They can often use their fullest powers on nights when the big ones are in serious trouble—"poor seeing" trouble.

Air turbulence and lack of tranquility at various heights in the atmosphere is the cause of most of this difficulty. Disturbed air makes the stars twinkle, and when we magnify the twinkle we cannot see the star for its apparent acrobatic explosions. Planetary detail becomes obliterated, shimmering in a fuzzy dance.

Questar's short barrel permits an easy demonstration of this phenomenon. If a lighted match is held a few inches below and ahead of the front lens, while some object is being viewed indoors in still air, the refractive power of the warm rarefied gases becomes evident. Multiple moving images overlay each other in the familiar pattern of bad seeing. And, of course, the bigger the aperture, the bigger the trouble with poor seeing.

That telescopes may be too large to define well may surprise many whose newspapers have assured them that "the new giant eye" will bring the moon "closer," certainly a wholly natural assumption. But the great reflecting telescopes are not built to look at moon or planets, which are more clearly seen with instruments of much more modest size. They were made to collect faint light in time exposures for astrophysical research. They can photograph the moon in very large scale, as the 200-inch has recently done, but without increased sharpness or better resolution of lunar features.

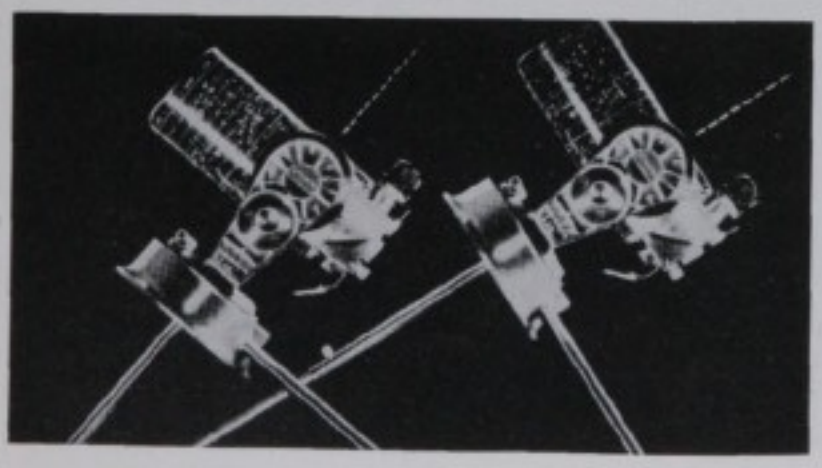
For the same reason of atmospheric difficulties, the power of magnification used by experts is usually moderate, often no more than Questar's 160 diameters, and sometimes even less. As usual, everything depends on tranquil air. The possessor of a large telescope chooses the best power for given seeing conditions, and it usually turns out that a relatively low power shows the finest detail, except on those rare occasions of unusually fine seeing.

"Empty magnification" is usually a thing the beginner has to learn first-hand. A telescope producing an image of the moon is using its fullest powers. We can observe the real image if we remove the eyepiece—it seems to hang there in the air, small and crisp. All the resolution is in this image, all the detail and contrast that our telescope can show. To examine the image, we select an eyepiece, which is only a special magnifying glass. A big low-power eyepiece shows the moon small. A medium eyepiece may just barely show it entire, while the highest power may fill the field of the eyepiece with only one-half the diameter, or one-fourth the area of the lunar image. In each case we only magnify what exists in that real image including all the faults and virtues. Of course, we assume fine eyepieces.

Questar's eyepieces are of exceptional quality. Each has two powers, as previously mentioned. The low power 40x is a three-lens Koenig type. The 80x is a five-lens Erfle eyepiece with the phenomenally wide field of 75°. With this eyepiece the moon is a glorious sight, and an impressive demonstration for Questar. There is no sensation of looking through a narrow tube as with the antique Huygens, Ramsden, or even some four-lens orthoscopic oculars. Rather, one seems to look through a nice big window.

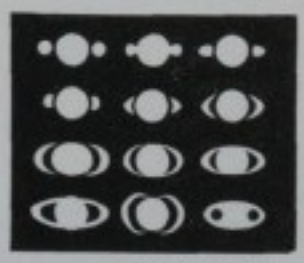
Which eye to use is a matter of choice, as is the use of spectacles. The thing is to do what comes naturally. Not everyone, even after long practice, can keep both eyes open as the microscopists recommend. But an open eye may be covered by the palm sometimes to good effect, and "palming" both eyes with cupped hands is most refreshing to tired eyes at any time.

The eye is living tissue, marvellously made and delicately poised within the all-embracing fabric of capillaries and blood vessels. Only constant nutrition and repair can keep its retina and nerve cells at peak sensitivity. To hostile cold or wind the eye responds with tears. Any kind of body strain, or a constriction of the neck arteries quickly registers itself in diminished vision. Even emotion or mood is able to affect the tone of our organism, of which the miraculous eye is but a part. The eye itself is also the last lens of any visual optical system, a point not always realized, for what good would be a telescope unfitted to this final living crystal?



The perfect environment for best seeing is from a seat indoors, away from insects, wind and chill. Until now, only the costly, complex polar telescope, with indoor eyepiece, met this condition. Now Questar, raised by the ingenious person above a windowsill, and penetrating a plastic cloth hung from opened sash, will provide a fine warmed-room observatory, with no light-loss from auxiliary mirrors.

Contrast is a vital factor in magnification. The smaller the power, the more concentrated the light, and vice-versa. In doubling magnification we have only one-fourth the light to express the relative brightness of areas that compose the image. It follows that the perception of fine detail, which is resolution, sharpness, depends upon degree of contrast as well as size of image, and in this matter people have personal preferences. The old rule of thumb says that telescopes should never be used at powers greater than 50 diameters per inch of aperture, for above this ratio all magnification is "empty," revealing nothing new.



Saturn drawings by early observers before Huygens' discovery of the ring in 1659.

It is possible by simple means to apply enormous magnification to any telescope's primary image. For example, any standard microscope can be used in place of eyepiece. We soon discover, however, that the image simply fades out. But long before it vanishes, the coarseness of everything seen becomes most objectionable. We seem but to enlarge all defects. The experienced observer keeps magnification moderate to secure a nice degree of contrast precisely because the human eye demands such a balance for sharpest perception. The novice only too often has been led to expect constant "high-power views" from his "high-powered telescope." What experience will have to teach him is how to get fine resolution from his "high-powered telescope" instead of empty magnification.

We must not expect any instrument to penetrate the haze and fog so apparent near the horizon in most climates without encountering a maximum of air disturbances and loss of contrast. The long view through the densest layer of air at horizon level reduces even the sun, so fierce above at noonday, to a quiet red disc at sunset. Dust and water vapor actually absorb all colors but the red rays, whose wave length is larger than the particles themselves. To demonstrate a telescope, particularly in cities, the nearer, more contrasty objects are preferable to distant views.

We may confidently expect to use Questar's 160 diameters frequently upon the moon's contrasty and brilliant disc, even in climates of normally mediocre seeing. As we have noted, small telescopes enjoy many advantages not shared by larger ones. They work particularly well upon the planets, especially on Jupiter and Saturn. But we must not expect too much from any telescope when objects are too close to the horizon. Venus seldom rises very high, nor does Mars at those times when its apparent size is greatest, and most suitable for observation. Unfortunately, Mars, at the closest opposition, is low in the sky, being well overhead only near the earth's equator. It is more rewarding to observe objects at least 30° above the horizon.

First Mars drawing, Huygens, 1659, shows Syrtis Major. Used 23' telescope of 2⅜" aperture, 100X.

Because of their size, small instruments are best upon bright objects and simply lack the light-collecting ability that is needed to intensify the contrast of nebulae or comets. Bearing this in mind, it is applicable to all the observing we do with Questar. In viewing nature, we should favor our instrument by seeking objects in full sunlight, or against a contrasting bright or dark background. Even in indoor close-up demonstrations, the value of bright illumination is at once evident.

The possessor of a small fine telescope may certainly expect a great deal from a minimum investment. For here too, the small instrument has considerable advantages. Dollar for dollar, small telescopes give us more for our money. Resolving power increases directly with aperture, a 7-inch resolving twice as well as a 3½ inch. But the weight and cost increase as the *cube* of any dimension! Not everyone is familiar with this fact, so well known in industry, but it is important to remember in contemplating a sizeable instrument.

The *Scientific American* for December, 1952, describes the work of Mr. James C. Bartlett, Jr., of Baltimore, a selenographer whose recent studies of the moon near the crater Fontenelle have resulted in the changing of lunar maps of that region. On the great Wilkins map of the moon the changed feature has been renamed "Bartlett" in his honor.

No serious person would have the temerity to suggest that original discoveries of this type can be expected to be made upon the moon except with instruments of considerable aperture, say from 6 to 12 inches. There are many telescopes of such sizes in use by observers all over the world, and the planets are under constant scrutiny, especially from that region of fine seeing, the southwest United States.

It is therefore a pleasure to report that the aperture of Mr. Bartlett's telescope is 3.5 inches.

(To be concluded)

WHAT TO EXPECT OF QUESTAR

The wonderful thing about owning a Questar is that this most versatile of all telescopes opens whole new worlds for our delighted eyes to explore. Accustomed as we are to single-purpose old-fashioned instruments whose form was set long before Mr. Fulton invented his steamboat, we may not fully realize how much more we can expect of Questar, the first truly modern telescope.

Perhaps the most important thing to expect is that you will find yourself using it more often than any telescope you have ever owned. You will probably discover that daytime terrestrial observing is more downright fun than you ever thought possible, and you may expect to get great pleasure from just looking at everything in sight wherever you find yourself. We ourselves have come confidently to expect fascinating views of interesting things quite invisible to the naked eye.

Of course you will expect to take it with you — not only on vacations, but wherever you go by car. Aside from its astronomical uses, and its impressive solar performance, there is the whole new realm of long-distance microscopy for your Questar to reveal. Do not expect to believe in the crystal clear beauty of this magic world only a few feet away in your garden until your own eyes have seen it. Then remember that no one has ever explored this world as you can, for no one ever had an instrument like Questar that could bring such powers to bear at such short distances. Here, the closer you are, the higher your powers, as Questar's focal length elongates for viewing near things.

Finally, you may expect to take truly remarkable pictures of what you have been seeing, by adding a camera body to your Questar. As the owner of not just a fine 42" telephoto lens, but a theoretically perect one, you may expect to find it unusually well adapted to the job of penetrating the layers of disturbed air along your line of sight when you take pictures of distant terrestrial objects. For this challenging and interesting work, Questar will be found worthy of your best skill and talent.

Questar comes complete with all accessories in an imported handmade English leather case at only $995. Your check for $300 will reserve an instrument, with balance due at time of shipment. Questar is shipped by prepaid parcel post, special handling, fully insured, in a reusable steel and fibre "Leverpak" drum, in which it floats on resilient preformed hair and latex padding.

We hope you will enjoy reading, on the opposite page, a reprinted section of the Questar booklet. The concluding section will be reprinted next month, and the whole booklet is available upon request.

QUESTAR CORPORATION
NEW HOPE, PENNSYLVANIA

Questar

OBSERVER'S PAGE

Universal time is used unless otherwise noted.

ASTROPHOTOGRAPHY FOR THE AMATEUR—III

FOUR photographic attachments for my 5½-inch refractor, as described in the January and February issues, provide the wide variety of film scales needed for photographing different astronomical subjects.

For large sky areas, such as whole constellations, one of two cameras is mounted on the telescope tube, providing either an f/3.5 lens of 3-inch focus or an f/4.5 6-inch lens. To photograph objects like star clusters, a camera device is used at the prime focus of the refractor's f/15 objective itself. When even larger scale is required, as in planetary work, this attachment is replaced by an eyepiece projection camera. I shall now discuss the practical use of this equipment.

When either of the two small cameras is employed, the 5½-inch telescope is used for guiding. Since this instrument has a good sidereal drive, the strain of guiding for 10 to 15 minutes is not too great.

Tracking must be even more accurate when the main telescope is to be used for prime-focus photography, and correct drive speed is of utmost importance. In this case guiding is accomplished with the finder, whose magnification is increased by the insertion of a Barlow lens. Sometimes there is no sufficiently bright guide star near enough to the object to be photographed. For this problem, I have made a tubeless scope for guiding on stars outside of the main field, but this device has not been thoroughly tested.

The moon is an easy object at the prime focus. Since the lunar image diameter averages about 1/110 the focal length, my refractor gives an image ¾" across. The intensely bright full moon requires short exposures, about 1/100 second; if a high-speed shutter is not available, exposure time can be lengthened by using a panchromatic emulsion and a filter. A gelatin filter can be placed near the film plane, but for a glass-mounted filter, remember that the focus

This 10-minute exposure of the constellation Cassiopeia, with the 6-inch f/4.5 camera, is enlarged 1.85 times.

The difference of film scale is well illustrated by comparing this picture of the Double Cluster with its appearance near the bottom of the Cassiopeia field above. The prime focus of the 5½-inch refractor was used for this exposure of 30 minutes, and the enlargement is 1.85 times. The focal length was 82½ inches, so the scale of the field is nearly 14 times that of the 6-inch camera. All photographs with this article are by Hans Pfleumer.

Your Personal Stairway to the Stars

THE BALscope Sr. TELESCOPE

The wisdom of dealing with traditional craftsmen is easily proved when you first use the BALscope, Sr. 60 mm telescope.

You can carry it anywhere . . . it's compact. Even the beginning amateur can focus with perfect accuracy, because of its unique prism-focusing system—the first *real* advance in telescope design in many years.

Use it on any pan-head camera tripod with the Bausch & Lomb tripod adapter and vary the power to suit the subject. Four easily interchangeable eyepieces ranging from 15× to 60× offer excellent results from Star Clouds to Double Stars.

Of course, it's also the finest terrestrial telescope available.

BALscope, Sr. with 15×, 20×, 30× or 60× eyepiece $95.00

Extra Eyepieces, each 25.00

Tripod adapter (permits use of BALscope, Sr. with any pan-head camera tripod) 6.85

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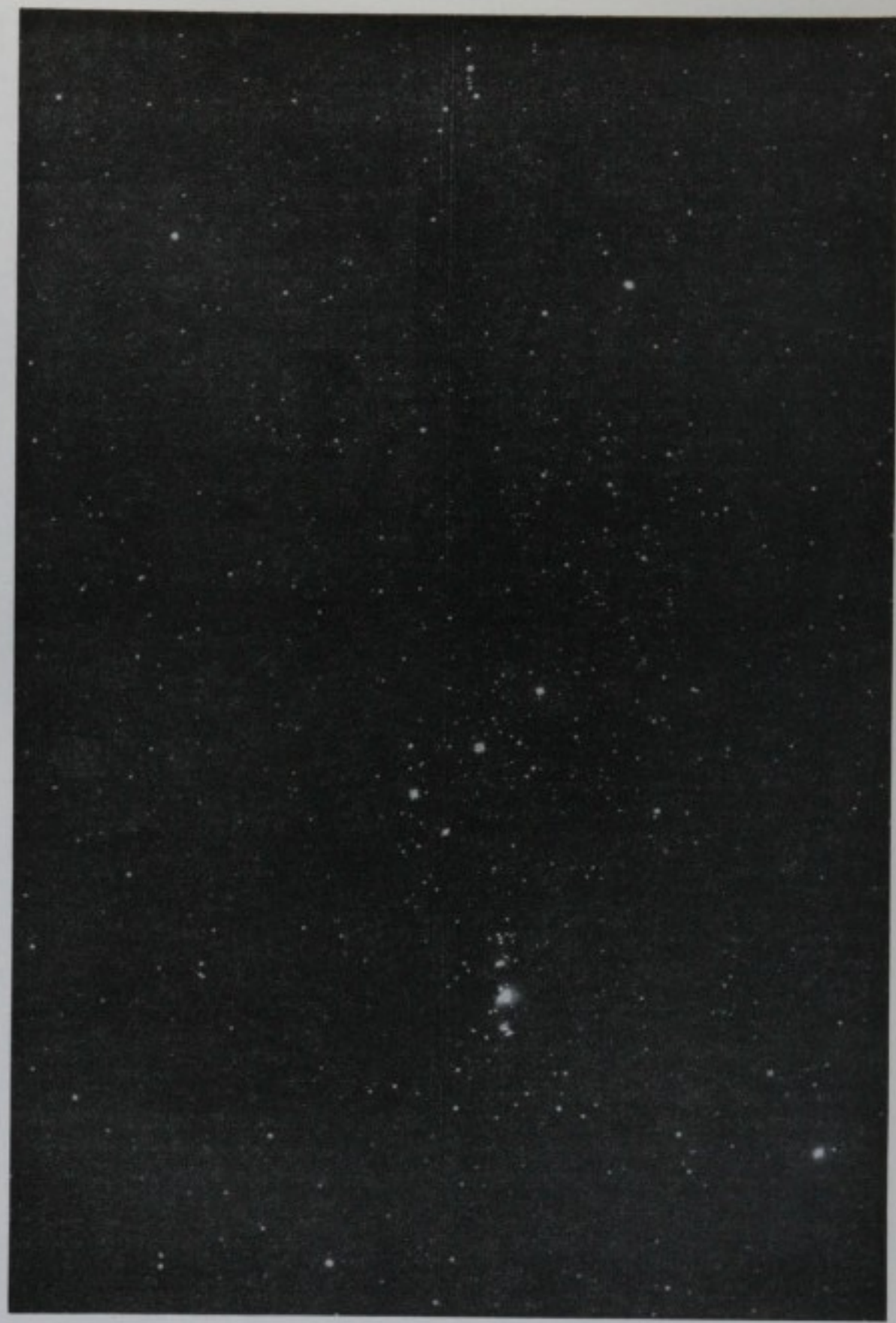

In this 10-minute exposure of Orion, with the 6-inch camera, the three belt stars are in the middle, with the sword and Great Nebula below them. Because it is red, Betelgeuse is relatively inconspicuous in the upper left. The development was eight minutes in D-19; enlargement, three times.

must be extended by one third the thickness of the glass.

One problem in photographing the moon near its quarter phases is that if correct exposure is given for the bright limb, the neighborhood of the terminator will be underexposed. I find that with the projection camera good results can be obtained, if the shutter in the square-tube section is moved partway back and forth to increase the exposure of the terminator relative to the limb. The shutter opening comes from the terminator side, and is stopped by a small clip from passing the full-open position; the shutter slide is then pulled back to its starting position. Of course, after a negative of the moon is developed, during the printing of enlargements the method of *dodging* may be used to control the relative intensities of the limb and terminator regions.

The projection camera, also used for planetary work, normally provides about five times the scale of the prime-focus device. Since the exposure times do not exceed a few seconds, guiding is not necessary, but the drive rate must be accurate. Sharp focusing is necessary, but often is difficult because the image seen through

The North America nebula is seen to the left of Deneb in this 15-minute exposure with the 3-inch f/3.5 Color Scopar camera, enlarged three times.

the ground-glass screen is faint. Rubbing the rough side of the glass with glycerin helps, and the image is examined with a 5x magnifier resting on the glass. A fine cross made on the ground side with a sharp No. 6 pencil is used to adjust the magnifier for its sharpest focus. As shown in the picture last month, I cemented a 90° prism to the eye end of the magnifier to make it easy to examine the image in any position of the telescope.

The proper length of exposure for projection photography varies as the square of the projection factor. For Saturn on Super Panchro Press film (type B, rating 125), I use an 8-second exposure with the f/15 objective and a ½-inch eyepiece 4½ inches from the film plane. This arrangement gives nine times the prime-focus scale, and the image of Saturn is ¾ millimeters in diameter.

The general procedure in taking a photograph is first to start the driving clock and to place the object on the finder crosshairs. Next the image is focused on the ground glass. After closing the shutter and installing the filmholder, the placement of the object in the finder is checked. The drive is allowed to run for a minute to take out any slack, and then the shutter is carefully opened to begin the exposure.

I use high-speed film (generally Super XX Pan), contrast-developed for 9 or 10 minutes in D-19. Glass plates are not necessary, for cut film is inserted in its packet in such a way that it curls against the filmholder and is held in the focal plane. I find that film scratches during development can be avoided by using a deep, round-cornered tray of kitchenware, of such a size that it supports the four corners of the film but does not let it touch the bottom. Such a tray is also used for washing.

Saturn and its rings.

HANS PFLEUMER
596 First Ave.
New Brunswick, N. J.

SUNSPOT NUMBERS

December 1, 80, 99; **2**, 83, 87; **3**, 71, 75; **4**, 79, 86; **5**, 75, 100; **6**, 85, 100; **7**, 80, 84; **8**, 67, 72; **9**, 79, 60; **10**, 63, 74; **11**, 57, 86; **12**, 60, 79; **13**, 69, 71; **14**, 57, 63; **15**, 75, 75; **16**, 54, 76; **17**, 70, 70; **18**, 63, 85; **19**, 94, 89; **20**, 91, 92; **21**, 78, 105; **22**, 62, 85; **23**, 44, 64; **24**, 47, 51; **25**, 45, 53; **26**, 54, 61; **27**, 64, 62; **28**, 62, 65; **29**, 73, 72; **30**, 63, 81; **31**, 48, 70. Means for December: 67.5 American; 77.2 Zurich.

Above are given the date, the American number, then the Zurich number. These are observed mean relative sunspot numbers, the American computed by D. W. Rosebrugh from AAVSO Solar Division observations, the Zurich numbers from Zurich Observatory and its stations in Locarno and Arosa.

The previously unreported American spot numbers for November, 1955, are:

November 1, 103; **2**, 88; **3**, 66; **4**, 58; **5**, 53; **6**, 51; **7**, 64; **8**, 85; **9**, 105; **10**, 125; **11**, 122; **12**, 121; **13**, 98; **14**, 108; **15**, 108; **16**, 81; **17**, 74; **18**, 71; **19**, 84; **20**, 67; **21**, 54; **22**, 40; **23**, 68; **24**, 68; **25**, 67; **26**, 78; **27**, 80; **28**, 90; **29**, 88; **30**, 95. Mean for November: 82.0 American.

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NEW MODEL "A", 6-inch **$295.00**
NEW MODEL "B", 8-inch **$375.00**

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We are now offering a new Richest Field ASTROLA, unmounted, 24" focal length, 6-inch mirror, with 28-mm. ocular. The tube is 26 inches long and the telescope may be cradled in the arms. **$125.00**

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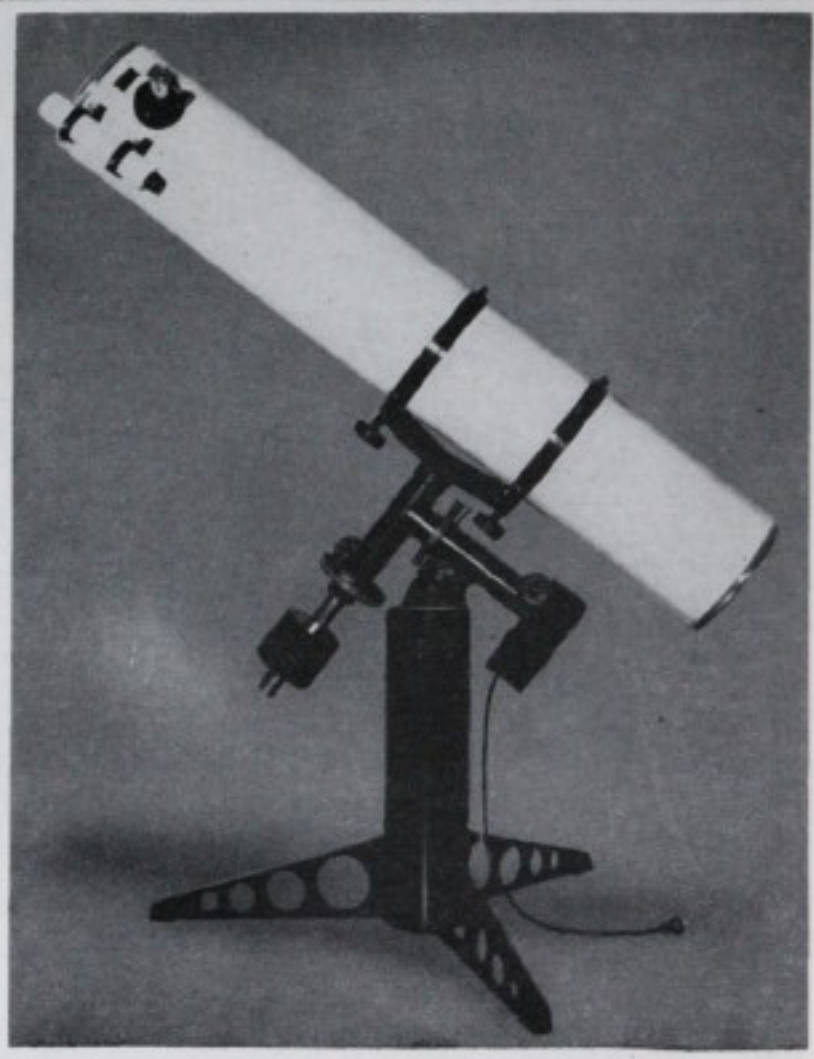
6" ..... **$ 60.00**
8" ..... **$ 92.50**
10" **$160.00**

All prices F.O.B. our plant, Long Beach, Calif., and subject to change without notice.

CAVE OPTICAL COMPANY
4137 E. Anaheim, Long Beach 4, Calif.



The above is the new De Luxe Model "B", 8-inch, with electric clock drive, setting circles, and rotating tube **$575.00**

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Only UNITRON offers such a wide variety of exclusive accessories to modernize your telescope and increase your observing pleasure.

UNICLAMP Camera Bracket: Completely new! The ideal means of attaching your camera to your telescope. The clamp encircles the tube and holds a screw threaded to fit the tripod socket of standard cameras.

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VIEW FINDER (As shown on UNITRON 2.4" Equatorial): 23.5-mm. (.93") achromatic objective. 6x eyepiece with crosshairs. Chromed brass tube. Mounting brackets with centering screws.

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DUETRON Double Eyepiece (Shown on the 3" Altazimuth): The new DUETRON double eyepiece literally doubles the usefulness of your UNITRON. Two observers may use the telescope simultaneously and with equal comfort. The two eyepiece holders may be turned independently with respect to the telescope tube to suit the convenience of each observer. A focusing sleeve is provided so that the eyepieces used need not necessarily be of the same magnification. DUETRON is a boon for father-and-son observing teams and for observers who buy their UNITRON in partnership, since it eliminates the need to take turns. With DUETRON, more observers may be accommodated at star parties, and the advanced members may provide valuable instruction to the beginners as they look through the UNITRON together. The DUETRON tube is interchangeable with the customary UNITRON drawtube and may be used with all models with the exception of the 1.6" Refractor.

Only $23.50 postpaid

PHOTOGRAPHIC GUIDE TELESCOPE: 62-mm. (2.4") diam., 700-mm. (27.5") focal length, coated, air-spaced, achromatic objective. 78x (9-mm.) achromatized symmetrical eyepiece with crosshairs. Star diagonal. Duraluminum tube finished in white. Dewcap. Rack-and-pinion focusing. Mounting brackets and centering screws for collimation. Fitted wooden cabinet.

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EQUATORIAL MOUNTING and TRIPOD: Complete with slow-motion controls for both declination and R. A., setting circles and verniers, and many other features.

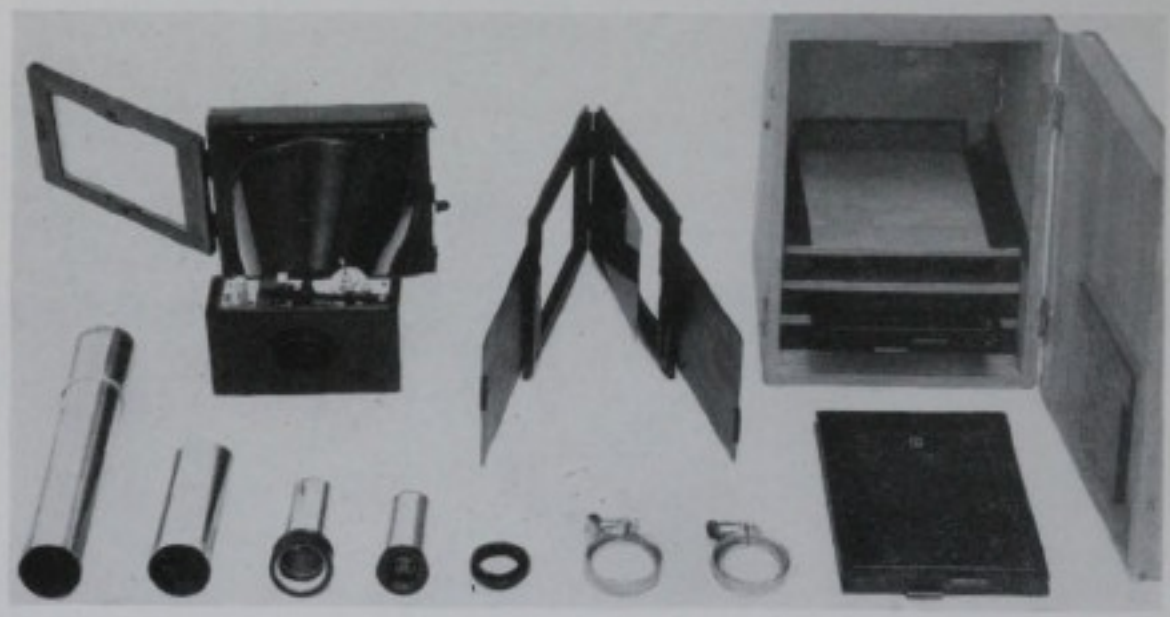
As used on UNITRON 3" Refractor — **$198**
As used on UNITRON 4" Refractor — **$370**

(These prices are f.o.b. Boston)

A noteworthy feature of UNITRONS is the large number of eyepieces included with each model as standard equipment and the additional ones available as optional extras. For example, with the popular UNITRON 2.4" Altazimuth Refractor, Model 114, 4 eyepieces come with the telescope and another 5 are available — a total of **9** different powers. The new UNITRON catalog illustrates the value of such a complete range of magnifications by a series of photographs of the moon, showing how the region around the crater Copernicus appears to an observer who views with eyepieces of different power.

This is but one of the many interesting features of the new UNITRON catalog, which contains the "Observers Guide" — a series of full-page, illustrated articles of general astronomical interest. Subjects covered include the "Constellations," "Observing the Sun," "Observing the Planets," "Wonders of the Deep Sky," "Amateur Clubs and Research Programs," "Hints on Observing," and "How to Choose a Telescope." There is also a glossary of telescope and observing terms (which is quite useful even though it fails to define the super-secret UNIZOR). Those interested in the doings of fellow amateurs will want to read the section, "The UNITRON Reporter," which contains 8 full pages of observation reports and photographs of UNITRON owners with their telescopes and observatories.

From the number of catalog requests received to date, it seems that just about everyone wants a copy, since **a**stronomers, **b**eing **c**urious, **d**elve **e**agerly for **g**enerally **h**elpful **i**nformation, **j**ests, **k**nowledge, **l**earning; **m**any **n**otes **o**f **p**raise — **q**uite **r**apturous — show **t**his **u**seful **v**olume **w**ill '**x**cite **y**our **z**est. Naturally there is no charge, and a letter or postcard will bring you a copy.



UNIHEX ROTARY EYEPIECE SELECTOR: The old-fashioned method of fumbling with eyepieces in the dark has been outmoded by UNIHEX, UNITRON's new Rotary Eyepiece Selector. With UNIHEX, you always have 6 magnifications ready at your fingertips. To change power, merely rotate a new eyepiece into position while the object stays centered and in focus in the field of view. If through inaccurate tracking you should lose the object under observation, you need only rotate the lowest power eyepiece into position to convert your telescope into a giant view finder, recenter the object in the field of view and rotate back to the higher powers. Model A is designed to fit the UNITRON rack and pinion and is for UNITRONS only. Model B fits 1¼" eyepiece holders. Complete with special clamping device and cabinet.

Model A or B — **Only $24.75 postpaid**

SUN PROJECTING SCREEN APPARATUS: White metal screen with matching black metal shade. Chromed brass extension rod with mounting brackets.

Set for 2.4" models — **Only $9.75 postpaid**
Set with screen 6" x 6" — **Only $13.50 postpaid**
Set with screen 7" x 7" — **Only $15.75 postpaid**

ASTRO-CAMERA 220 (Illustrated above): With this camera, owners of altazimuth models can photograph the sun, sunspots, the moon, and solar and lunar eclipses. An equatorial model is required for recording other celestial objects which need longer exposures, and the clock drive is essential for prolonged tracking. The camera uses an air-operated curtain shutter of the Thornton-Pickard type, giving speeds of 1/10 to 1/90 second in addition to bulb and time. The camera may be positioned so that the plane of the film passes through the focal point of the objective, which is then the only optical element. When magnification of the primary image is desired, an eyepiece can be inserted into the camera tube and an image projected on the film. Astro-Camera 220 comes complete with ground-glass back, 3 double plate-holders for 3¼" x 4¼" plates or cut film, a 30-mm. f.l. eyepiece, extension tubes and clamps to lock the camera firmly in place, air-operated bulb release (not illustrated), removable filter, and a fitted wooden cabinet. Model A is designed to fit the UNITRON rack and pinion replacing the customary drawtube and is for UNITRONS only. Model B fits 1¼" eyepiece holders.

Model A or B — **Only $69.50 postpaid**

See the back cover.

United Scientific Co. 204-206 MILK STREET, BOSTON 9, MASS.

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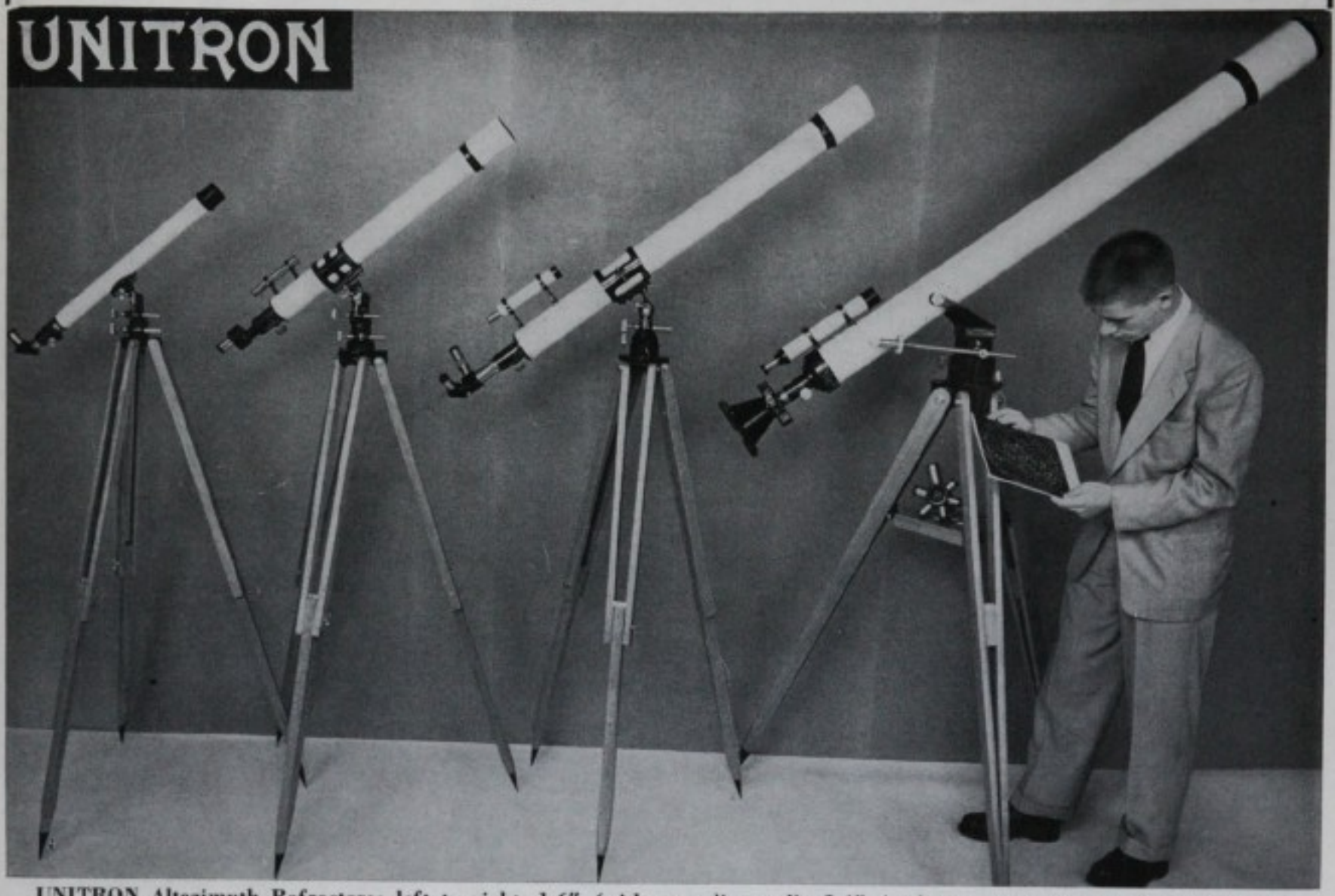


UNITRON Altazimuth Refractors: left to right, 1.6″ (with star diagonal), 2.4″ (with erecting prism system), 3″ (with DUETRON double eyepiece), and 4″ (with astro-camera and UNIHEX on the shelf).

Eleven Models To Choose From!

1.6″ ALTAZIMUTH ($19 Down) **$75**
with eyepieces for 78x, 56x, 39x

2.4″ ALTAZIMUTH ($31 Down) **$125**
with eyepieces for 100x, 72x, 50x, 35x

2.4″ EQUATORIAL ($56 Down) **$225**
with eyepieces for 129x, 100x, 72x, 50x, 35x

3″ ALTAZIMUTH ($66 Down) **$265**
with eyepieces for 171x, 131x, 96x, 67x, 48x

3″ EQUATORIAL ($108 Down) **$435**
with eyepieces for 200x, 131x, 96x, 67x, 48x

3″ PHOTO-EQUATORIAL ($137 Down) **$550**
with eyepieces for 200x, 171x, 131x, 96x, 67x, 48x

4″ ALTAZIMUTH ($116 Down) with **$465**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x

4″ EQUATORIAL ($196 Down) with **$785**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x

4″ PHOTO-EQUATORIAL ($222 Down) **$890**
with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x

4″ PHOTO-EQUATORIAL with clock **$1175**
drive and astro-camera ($294 Down) with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x

4″ PHOTO-EQUATORIAL with clock **$1280**
drive, fixed pier, astro-camera ($320 Down) with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x

Additional eyepieces available for all models.

- LENSES are FULLY CORRECTED for spherical and chromatic aberration and are COATED for maximum brilliance and clarity of image. Optics especially designed for astronomical observation. AIR-SPACED OBJECTIVE.
- EYEPIECES of the HIGHEST QUALITY: Orthoscopic, Achromatized Symmetrical, Kellner, Huygens. Three to eight eyepieces included with each instrument as standard equipment.
- FINEST MATERIALS throughout. DURALUMINUM TUBE. Moving parts of BRASS carefully machined to close tolerances, and finished in CHROMIUM. No war surplus components used.
- MODERN DESIGN based on time-tested engineering principles. HANDSOME APPEARANCE to which no illustration can do justice.
- EQUATORIAL MODELS have slow-motion controls for *both* declination and right ascension as well as rapid-motion controls. Sturdy TRIPOD.
- ALTAZIMUTH MODELS have slow-motion controls for *both* altitude and azimuth as well as clamps for both co-ordinates. Sturdy TRIPOD.
- VIEW FINDER with crosshair eyepiece.
- RACK-AND-PINION FOCUSING.
- Choice of UNIHEX Rotary Eyepiece Selector or STAR DIAGONAL and ERECTING PRISM for TERRESTRIAL OBSERVATION. The same complete range of terrestrial magnifications as for celestial observation.
- SUNGLASS for solar observation.
- SUN PROJECTING SCREEN is standard equipment on 3″ and 4″ Equatorial Models and available for other Models.
- Complete operating INSTRUCTIONS provided.
- FITTED WOODEN CABINETS.

Use Our EASY PAYMENT PLAN

The UNITRON Easy Payment Plan is a convenient and economical way to buy your UNITRON Refractor when you do not want to disturb your savings or when you haven't the total cost of the telescope immediately available. The down payment required is 25%. The balance due is payable over a 12-month period, and there is a 6% carrying charge on the unpaid balance. Your first payment is not due until 30 days after you receive the instrument, and if you should want to pay the entire balance due at that time, the carrying charge is canceled.

There is no "red tape" when you order — you merely fill in the UNITRON Easy Payment Order form, return it to us together with the required down payment, and the model of your choice is shipped to you at once. Whether you buy your UNITRON on the Easy Payment Plan or pay for it all at once, your purchase will bring you a lifetime of trouble-free enjoyment. Far more UNITRONS are sold than any other equivalent telescopes — there must be a reason!

HOW TO ORDER

Send check or money order in full or use our Easy Payment Plan, as described above. Shipments made express collect. Send 20% deposit for C.O.D. shipment. All instruments fully guaranteed.

NEW Higher-Power Eyepieces Available

Accessory orthoscopic eyepieces of 4-mm. and 5-mm. focal lengths are now available for your UNITRON at $14.75 each, postpaid. These give magnifications as follows: 4″ models, 375x and 300x; 3″ models, 300x and 240x; 2.4″ models, 225x and 180x.

United Scientific Co. 204-206 MILK STREET, BOSTON 9, MASS.

SKY-GAZERS EXCHANGE

Classified advertising costs 15 cents a word, including address; minimum charge, $3.00 per ad. *Remittance must accompany order.* Insertion is guaranteed only on copy received by the 20th of the second month before publication; otherwise, insertion will be made in next issue. We cannot acknowledge classified ad orders. Sky Publishing Corporation assumes no responsibility for statements made in classified ads, nor for the quality of merchandise advertised. Write Ad Dept., Sky and Telescope, Harvard Observatory, Cambridge 38, Massachusetts.

WANTED: Tripod mount for 4" refractor. Equatorial, slow motions, steady. Can do with head alone. Robert K. Leavitt, 31 Walbrook Rd., Scarsdale, N. Y.

TELESCOPES and all accessories bought, sold, or exchanged. Valley View Observatory, 106 Van Buren St., Pittsburgh 14, Pa. Established 25 years ago.

SEAMLESS FIBERGLASS telescope tubes for discriminating amateurs preferring the best. Painted. Ready for optics. Write W. Parks, 16815 Faysmith, Torrance, Calif.

FOR SALE: 12½" pyrex telescope mirror, f/6.5, with 2" hole in center for Cassegrainian focus; is aluminized, but lacks ½" of being fully polished to edge; will send tool on request; $100.00. 8" f/12 pyrex mirror, professionally made and aluminized, $70.00. 16" pyrex mirror blank and tool, mirror is 3" and tool 1½" thick, with channeled lap, $70.00. Jimmy Dail Rouse, 1203 Indian Creek Rd., Brownwood, Tex.

FOUCAULT TESTERS, mirror testing racks, beeswax-coated pitch squares. Buy these time-saving items. Quality optics. Harold Snyder, Walbridge, Ohio.

6" REFLECTOR, f/7. Fork-type equatorial mount. 3 eyepieces and Goodwin Barlow included. Quality components throughout. $160.00. T. Brown, 261 N. Hillcrest, Inglewood 1, Calif.

ASTRONOMICAL SLIDES: 35 mm. For teachers, lecturers, amateurs, professionals. Only 25¢ each. New free catalogue. Martin Kantor, 129 Rockaway Parkway, Brooklyn 12, N. Y.

MIRROR 12" f/4 with elliptical diagonal in cell; never used; surface correction to ⅛ wave; both aluminized. $325.00. B. Wacek, 2901 Remington, Baltimore 11, Md.

PALOMAR postage stamps. 50¢ dozen mint. Other astronomicals available. Stamp collectors catalogue free. Collections purchased. Hammond D78S, Crystal Beach, Fla.

WANTED to buy: One 16" diameter pyrex blank. Contact Edward Leibhardt, 1400 South 14th Ave., Maywood, Ill.

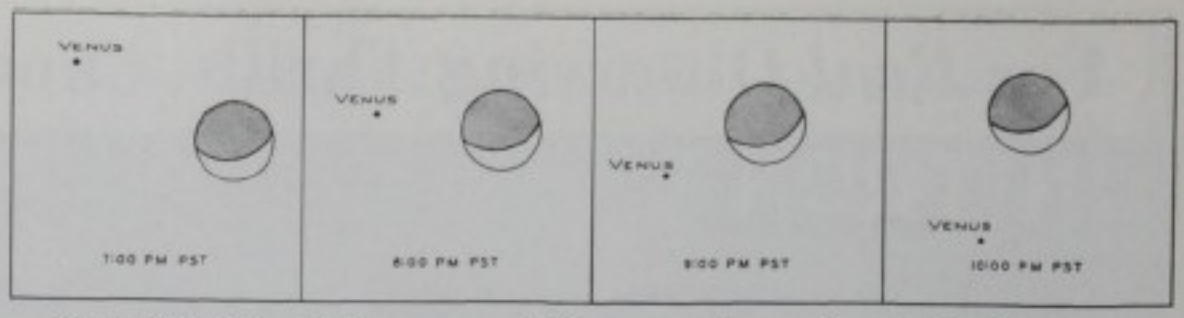
MIRROR MAKERS: The pitch lap mold as described by Allyn Thompson assures a good figure with minimum effort and experience. Send $2.00 for a rubber mold ready to use. State size of your mirror. Satisfaction or money back. R. L. Hargraves, P. O. Box 2510—Merchants Station, St. Louis 2, Mo.

PRECISION CLOCK, Hope Jones type, Synchronome electric with seconds dial, like new, factory-made, in case, $300.00. B. A. Wacek, 2901 Remington Ave., Baltimore 11, Md.

FOR SALE: 6" f/10 reflecting telescope. Won first prize for design at Stellafane, 1954 (*Sky and Telescope*, November, 1954). Rotating tube, cable slow motion, drives, setting circles. $700.00. Worth much more. Albert Robinson, 41 Truman Rd., Newton Centre, Mass.

3" REFRACTOR. For sale: 3" Unitron altazimuth refractor. All accessories and instrument like new. Original cost $265.00. Special price $169.50. Shipped express collect. R. R. Richardson, Jr., 927 McKinley Blvd., Alton, Ill.

PANORAMIC TELESCOPES, M6, for sale, 4 power, 10° field vision, U. S. Army surplus, manufactured by Warner and Swasey. Consists of gear reduction unit ideally suited for clock drive equatorial mount with position-indicating window and brake mechanism; 3" focal length objective lens 11/16" diameter; ¾" focal length flat field achromatic eyepiece, 4-lens system; elbow telescope containing the above optics suitable for 4x finder, especially on reflector. Also includes dovetail prism 9/16" faces; right-angle prism 7/8" x 15/16" faces; optical flat; cross-hair reticle. Over-all dimensions 8" long by 3½" diam. Entire unit at only $12.95 postpaid. Original government cost $800.00. Limited quantity available. Farber Products Co., Inc., Dept. Y, 226 Lafayette St., New York 12, N. Y.



The conjunction of the moon and Venus on the evening of March 15th, as seen looking toward the west from San Francisco.

VENUS AND THE MOON IN CONJUNCTION

DURING the evening hours of Thursday, March 15th, observers throughout the United States and Canada will be able to see the 3½-day-old crescent moon and brilliant Venus form a beautiful close pair in the low western sky.

For viewers in eastern states, the moon will set before it overtakes the planet. Observers on the Pacific Coast, however, can watch the moon pass only a lunar diameter north of the planet. From the Arctic and the North Pacific Ocean, Venus will appear occulted.

The accompanying diagrams chart the course of the conjunction as seen from San Francisco in California. This sequence of positions applies approximately for other places in the United States, if the time labels are converted from Pacific standard time to the appropriate zone time. For more easterly observers one or more of the diagrams, counted from the right, will correspond to configurations after moonset.

At San Francisco, moonset on March 15th is at 10:00 p.m. PST. As seen from there, the distance of Venus from the moon's center will be 1° 10′ at 7 p.m., 51′ at 8 p.m., 44′ at 9 p.m., and 54′ at moonset. The apparent altitude of the moon at these times will be 33°, 22°, 10°, and 0°, respectively, at San Francisco.

This springtime Venus-moon conjunction will be a particularly spectacular one. The planet is at not much less than its maximum brightness, and its setting time is nearly the latest possible for observers in north temperate latitudes. These circumstances will make the conjunction an opportunity for several kinds of striking photographs.

For example, the spectacle can be included with foreground objects, or the evening sky glow can be exposed ahead of time to show a silhouette horizon with the moon and Venus above it. Only simple camera equipment will be needed for long exposures that record the trails of both objects and the manner in which horizon haze dims them as they set. Telescopes can be used for closeups in which the gibbous phase of Venus contrasts with the crescent of the moon; a series of these shots will show the change in relative position of the two objects.

Sky and Telescope will welcome photographs of this conjunction for possible publication. These should be glossy prints, black and white, carefully packed to avoid damage in the mail, and should reach us by March 27th for inclusion in the May issue. Full details of observing equipment and photographic processing should be included with each picture.

J. A.

DEEP-SKY WONDERS

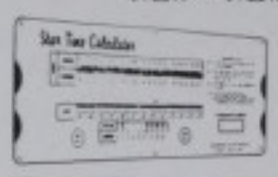
ONE of the most interesting types of record an amateur observer of nebulae can keep is that of night-to-night visibility. The apparent brightness of an object depends on much more than the size of the telescope. Sometimes equally important are the nature of the air mass over the station, the amount of cirrus and aurora in the sky, moonlight, and perhaps other yet unsuspected atmospheric influences.

An amateur who would select a small list of nebulae around the sky, and every clear night with the same instrument painstakingly record the exact appearance, the brightness, and perhaps the maximum diameter of each object, would turn up with most useful data after a few years. The record should include the time of each observation, and information on the sky conditions.

Once such a list were made, weather records could easily be found and correlations sought. Because some of our readers write that they are looking for new trails to blaze, this program is suggested. It would be hard work, but, if well carried out, could perhaps contribute to the coming International Geophysical Year.

For this time of year, we suggest the following objects, one of which might

NEW - NEW - NEW



Star Time Calculator

Handy slide-rule type calculator enables you to obtain sidereal time in a matter of seconds. Good for any longitude, day of the year, standard time zone, and time of day. Accuracy to within several minutes is more than adequate for setting-circle use. Printed in two colors on sturdy 10" x 3½" cardboard. Reverse side lists 39 major star clusters and nebulae.

A useful tool for all who are interested in astronomy. Satisfaction guaranteed.

$1.00 postpaid

STAR TIME CALCULATOR

RR 2, Box 375, Buchanan, Michigan

prove suitable for your telescope and location. Readers who have back files of this magazine will find location charts in the March, 1949, issue. All three are plotted in the Skalnate Pleso atlas.

NGC 2683, at $8^h\ 49^m.6$, $+33°\ 38'$ (1950) in Lynx, is a 10th-magnitude spiral, 10-by-1 minutes of arc in size.

NGC 2781, $9^h\ 09^m.1$, $-14°\ 36'$, is a 12th-magnitude, 1.3-by-0.4-minute barred spiral in Hydra.

NGC 2855, also in Hydra and at $9^h\ 19^m.1$, $-11°\ 41'$, is a spiral 1.3 minutes in diameter and of the 12th-magnitude.

Obviously, however, any galaxy that is not too easy in your telescope can serve as a systematic test object. Observers with small instruments may find it convenient to choose Messier objects.

WALTER SCOTT HOUSTON
Rt. 3, Manhattan, Kans.

MOON PHASES AND DISTANCE

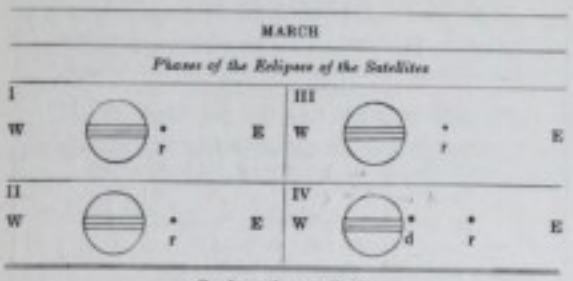
Last quarter	March 4, 11:53
New moon	March 12, 13:36
First quarter	March 19, 17:13
Full moon	March 26, 13:11
Last quarter	April 3, 08:06

	March	Distance	Diameter
Apogee	6, 13^h	251,500 mi.	29′ 32″
Perigee	22, 0^h	229,200 mi.	32′ 24″
	April		
Apogee	3, 10^h	251,100 mi.	29′ 34″

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the *American Ephemeris and Nautical Almanac*.



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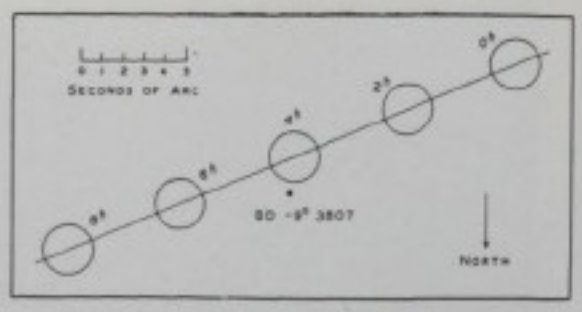

This diagram has south at the top, as in an inverting telescope. Star and planet will be nearly equally bright. Universal time is shown.

CLOSE APPULSE OF NEPTUNE TO A STAR

ON Friday evening, March 9th, observers in the Americas can watch the planet Neptune pass only 1.7 seconds of arc south of the 7½-magnitude star BD −9° 3807. The 1950 position of this star is $13^h\ 54^m.0$, −9° 47′; it may be easily identified on the chart of Neptune's path given on page 191 of the February issue.

The least separation of star and planet occurs at 4:18 Universal time on March 10th, which corresponds to 11:18 p.m. Eastern standard time on the 9th. Since the angular radius of Neptune on this date is 1″.2, its disk will clear the star by about 0″.5. Uncertainties in the catalogue position of the star and in the ephemeris of Neptune leave the bare possibility that an occultation may occur.

This appulse is predicted in the 1956 *Handbook* of the British Astronomical Association, but the least separation is given there as 5″. The present calculation is based on the Boss *General Catalogue* position of the star, converted to apparent place, and the *American Ephemeris* predictions for Neptune. Geocentric parallax, which can alter the planet's position by 0″.3 only, was not taken into account. J. A.

VARIABLE STAR MAXIMA

March 1, T Centauri, 133633, 6.1; 3, S Carinae, 100661, 5.7; 7, R Sagittarii, 191019, 7.2; 15, S Herculis, 164715, 7.6; 17, R Geminorum, 070122a, 7.1; 22, V Coronae Borealis, 154639, 7.4; 23, U Ceti, 022813, 7.5; 29, R Reticuli, 043263, 7.7; 30, S Hydrae, 084803, 7.9.

April 4, RS Librae, 151822, 7.7; 4, V Ophiuchi, 162112, 7.5; 4, T Herculis, 180531, 8.0; 6, R Caeli, 043738, 8.0.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

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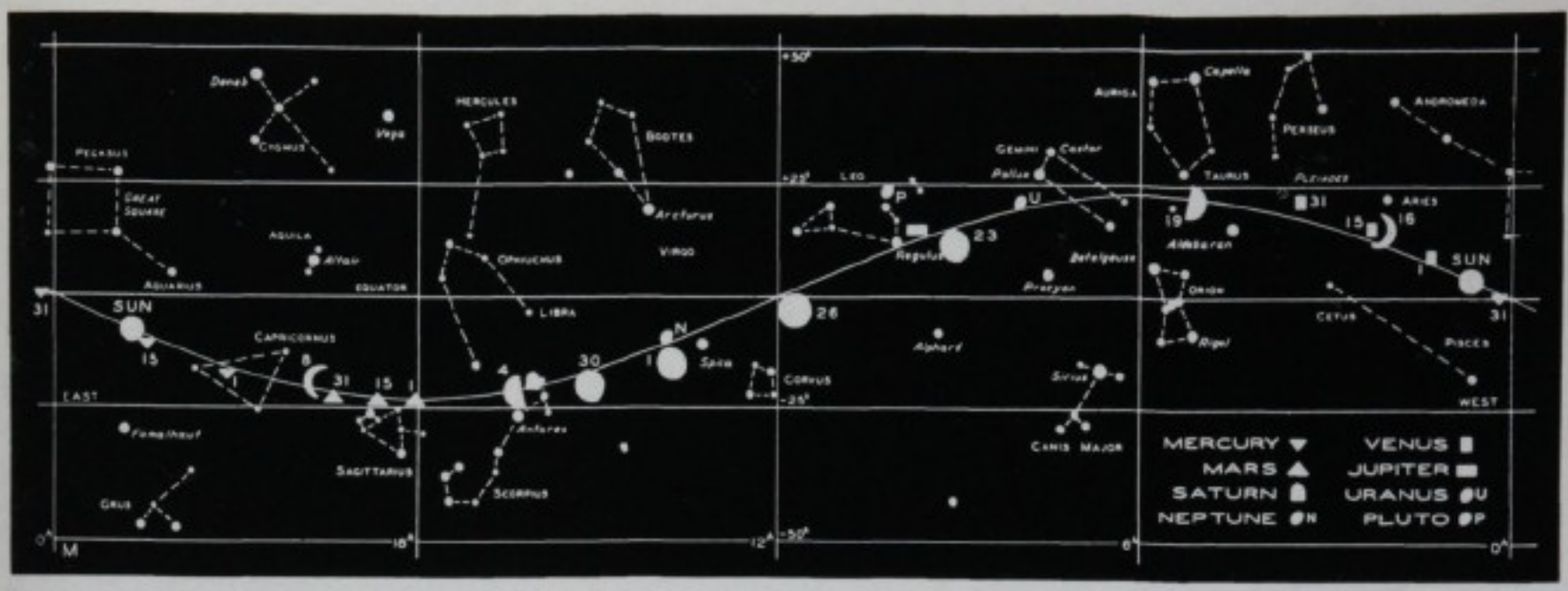

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury is in the morning sky all month, but will be very difficult to see. In early March, the planet rises only an hour before the sun, and this interval shortens steadily through the month.

Venus continues as a brilliant evening object, setting nearly four hours after the sun by midmonth. The planet moves from Pisces through Aries into Taurus during March. On the 16th at 3:41 UT, Venus will be in conjunction with the moon, the former 1° 07′ to the south, as seen from the center of the earth. The disk of Venus will be 18″ in diameter and 65-per-cent illuminated on March 15th, when the planet shines at magnitude −3.7.

Earth arrives at heliocentric longitude 180° on March 20th at 15:21 UT. Spring begins in the Northern Hemisphere and autumn in the Southern, with days and nights approximately equal over the earth.

Mars rises 3½ hours before the sun in mid-March, appearing at magnitude +1.0. The red planet continues in eastward motion through Sagittarius.

Jupiter crosses the meridian in late evening, and sets shortly before sunrise. Now located about 6° west of Regulus in Leo, Jupiter continues its retrograde (westward) motion. On the 15th, when the magnitude of the planet is −2.0, its telescopic disk is 44″ in equatorial diameter.

Saturn may be seen rising in the southeast about midnight in early March, appearing at magnitude +0.6. The planet remains about 1° north of Beta Scorpii all month, as retrograde motion commences on the 12th. The ring system is inclined 24°.8 to our view in midmonth.

Uranus, in western Cancer, is traveling slowly westward. The position of this 6th-magnitude object on March 15th is right ascension $8^h\ 02^m.2$, declination +21° 02′ (1950 co-ordinates).

Neptune, rising about 2½ hours after sunset, can be picked up with binoculars. In Virgo about 8° east of Spica, this distant 8th-magnitude planet will be at $13^h\ 53^m.7$, −9° 49′ (1950) on the 15th. Charts of the paths of both Uranus and Neptune are given on page 191 of the February issue.

E. O.

OCCULTATION PREDICTIONS

March 2-3 **Delta Scorpii** 2.5, 15:57.7 −22-29.9, 21, Im: **E** 11:35.4 ..... 163. Em: **E** 12:14.5 ..... 213.

March 18-19 **o Tauri** 4.8, 5:25.0 +21-54.1, 7, Im: **F** 6:00.5 −0.5, −0.1 60; **H** 5:42.8 −1.0 −0.7 76; **I** 5:40.4 ..... 28.

March 19-20 **Nu Geminorum** 4.1, 6:26.4 +20-14.5, 8, Im: **D** 6:08.5 +0.4 −1.9 134; **E** 6:22.3 +0.7 −2.7 158.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** − **LoS**), and multiply **b** by the difference in latitude (**L** − **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

PREDICTIONS OF BRIGHT MINOR PLANET POSITIONS

Amphitrite, 29, 9.3. March 8, 12:47.7 −6-30; 18, 12:39.5 −6-04; 28, 12:30.2 −5-30. April 7, 12:20.9 −4-53; 17, 12:12.5 −4-18; 27, 12:06.0 −3-52.

Thalia, 23, 9.7. March 18, 13:55.2 +3-08; 28, 13:47.6 +3-44. April 7, 13:38.3 +4-12; 17, 13:28.4 +4-25; 27, 13:19.2 +4-21. May 7, 13:11.8 +3-58.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

MINIMA OF ALGOL

March 1, 16:33; 4, 13:22; 7, 10:11; 10, 7:00; 13, 3:50; 16, 0:39; 18, 21:28; 21, 18:18; 24, 15:07; 27, 11:56; 30, 8:45. April 2, 5:34; 5, 2:24; 7, 23:13; 10, 20:02.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

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STARS FOR MARCH

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of March, respectively; also, at 7 p.m. on April 7th. For other dates, add or subtract ½ hour per week.

This year the bright planet Jupiter is very conspicuous in that part of the sky that is to the east of the meridian at chart time. This region usually seems dim in comparison to the bright stars of winter, which are now all in the western heavens.

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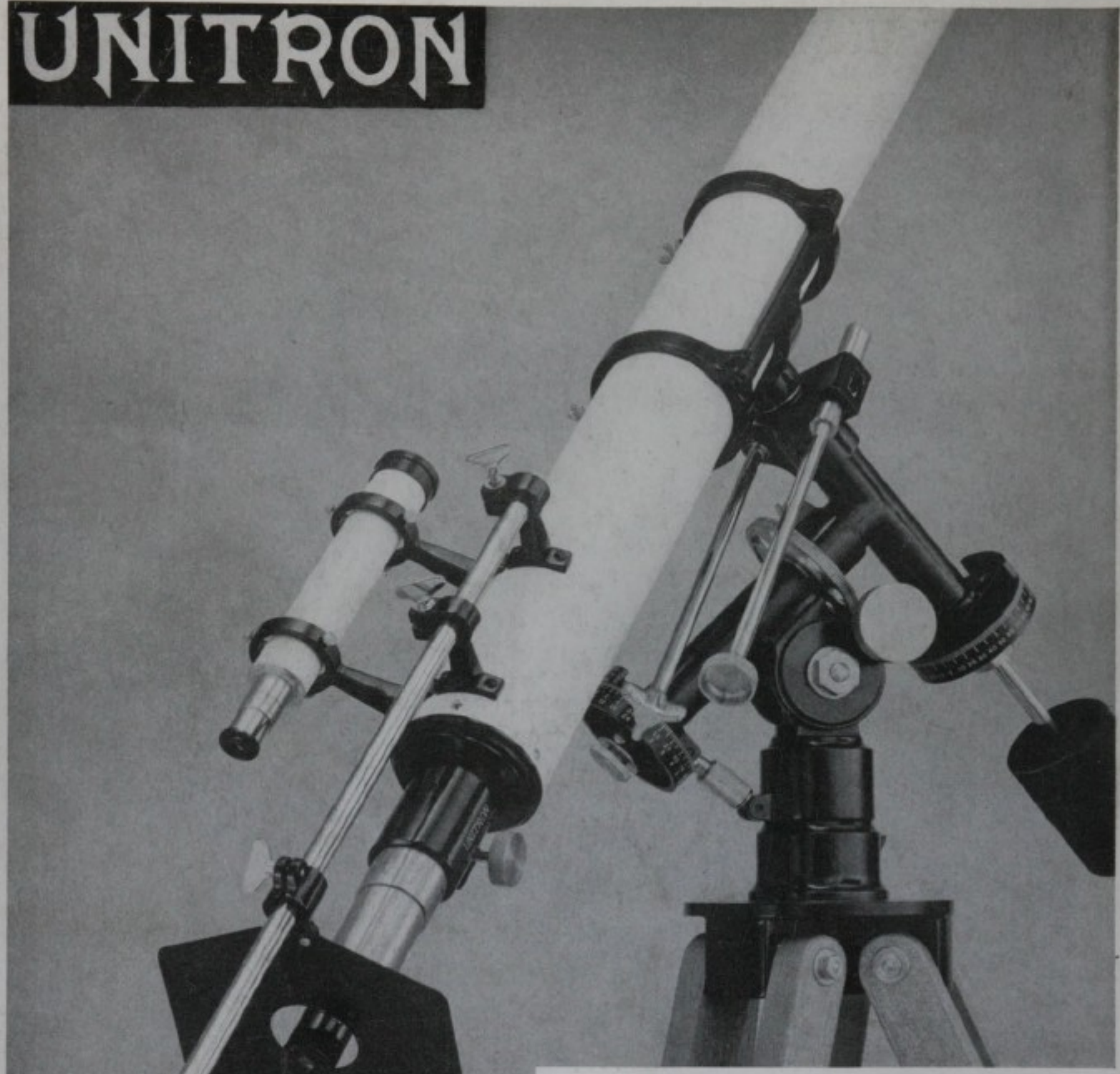

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See pages 236 and 237.

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